ENACTING AGENCY: UNDERSTANDING HOW FIRST-GENERATION COLLEGE STUDENTS' PERSONAL AGENCY SUPPORTS DISCIPLINARY ROLE IDENTITIES AND ENGINEERING AGENCY BELIEFS

by

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Para mi Papá, the hardest working man I've known, I wish you could have seen the fruit of your labor,

para mi Mamá, the strongest woman I know,

para mis hermanos y hermanas, the most resilient people I know,

y

finalmente para todos los que un día serán the FIRST in their family

.

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ABSTRACT

Educating engineers should be for the benefit of students and their aspirations, whether that is helping their communities and/or environment, achieving financial stability, or achieving the goal of earning a degree in a lucrative field. Obtaining an engineering degree positions students as capable agents for societal change, which are not limited to solving global concerns, societal issues, or personal problems. This work examines how students who are the first in their families to attend college come to see themselves as agentic engineering participants so that their experiences can inform engineering educators of the strategies of perseverance they enact. Specifically, the three studies presented use an asset-based perspective to understand how first-generation college students' through their agentic capabilities are enabled to participate in engineering. Study 1 develops a measurement scale to capture first-generation college students' agency using the constructs of intentionality, forethought, self-reactiveness, and self-reflectiveness. Strong validity evidence for the second-order latent construct of personal agency was established through exploratory and confirmatory factor analysis. Study 2 used structural equation modeling to establish a relationship between personal agency, disciplinary role identities, and students' desire to enact engineering agency. First-generation college students' personal agency had the greatest effect on their perception of enacting purposeful and meaningful change (i.e., engineering agency). Additionally, personal agency had the strongest effect on first-generation college students' engineering identity when compared to mathematics identity and physics identity. Lastly, Study 3 was a narrative analysis of how Kitatoi, a Latina, first-generation college student, authored her identity as an engineer. The process of authoring an identity happens over daily encounters and struggles. Taking into consideration students' backgrounds is important for understanding how disciplinary role identities develop. Kitatoi's pathway while in community college allowed her to develop an identity in the context of mathematics and physics, and once in Research State University, through her agency, she came to see herself as a capable engineering learner. Personal agency allows educators to acknowledge that students are authors of their actions, and their actions, when targeted in the context of engineering, have engineering identity-forming outcomes. These studies create an asset-based body of work on first-generation college students and build theory about how this group of students through the enactment of their personal agency develop an engineering identity and use engineering as a tool to make a difference in the world.

1. INTRODUCTION

1.1 Motivation

Engineering education for all students needs to be different than engineering for the purpose of increasing throughput, filling the pipeline, or national competitiveness; a discourse found in numerous national reports (e.g., National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007, 2010; President's Council of Advisors on Science and Technology, 2012). Educating engineers should be for the benefit of students and their aspirations, whether that is helping their communities and/or environment, achieving financial stability, or achieving the goal of earning a degree in a lucrative field. I echo the sentiments addressed by the American Association of the Advancement of Science (AAAS) in their 1989 *Science for All Americans* book, "Education has no higher purpose than preparing people to lead personally fulfilling and responsible lives … The world has changed in such a way that science [and engineering knowledge] … has become necessary for everyone, not just a privileged few …" (p. xiii). Thus, shifting from a market perspective to a student-center approach, educating future engineers should be for the benefit of students, themselves, and for the benefit of their communities and/or environment. Obtaining an engineering degree positions students as capable agents for societal change, which are not limited to solving personal problems, societal issues, or global concerns. A more recent report by the National Academies of Sciences, Engineering, and Medicine, which sought to understand the barriers and opportunities that support diverse students' pathways into STEM-fields, emphasized a similar sentiment. The report noted that investment in education for everyone is necessary for the development of society and advocates that "reforms be learner centered and that the system be viewed from the perspective of the learners" (National Academies of Sciences Engineering and Medicine, 2016, p. xii). The report stated that students should be granted the opportunity to earn a STEM degree with the least amount of obstacles (National Academies of Sciences Engineering and Medicine, 2016). However, challenges to degree completion and entry into the engineering community of practice do exist, and these obstacles (i.e., push out culture of engineering, negative experiences, and stereotype and identity threat, to name a few) are often compounded for students who are underrepresented in engineering.

I examined how students who are the first in their families to attend college come to see themselves as capable engineering participants so that their experiences can inform engineering educators of the strategies for perseverance they enact. Specifically, my dissertation studies use an asset-based perspective to understand how first-generation college students' through their agentic capabilities are enabled to participate in engineering. My three studies were motivated by the following:

1) The need to portray the first-generation college student population through an asset-based perspective.
2) The need for the engineering education community to understand that while there are environmental factors that impinge on first-generation college students' progression, they are also agentic individuals that can act on their environment.
3) The need to build theory of how first-generation college students come to see themselves as engineers and enact their agency.

The three motives I outline position first-generation college students in engineering as active participants, active agents of their academic trajectory, and they serve as guides for my dissertation studies. These three motives were created as a counter to deficit-based literature of first-generation college students, which are centered around lack of academic preparation (Engle, 2007; Redford & Mulvaney Hoyer, 2017; Saenz, Hurtado, Barrera, Wolf, & Yeung, 2007), inadequate familial support (Raque-Bogdan & Lucas, 2016), challenges towards achieving future career goals (Fernandez, Martin Trenor, Zerda, & Cortes, 2008), challenges faced when transitioning from secondary to postsecondary education (Pascarella, Pierson, Wolniak, & Terenzini, 2004) and lack of social and cultural integration (Kuh, Kinzie, Buckley, Bridges, & Hayek, 2006; Stephens, Fryberg, Markus, Johnson, & Covarrubias, 2012). The aforementioned studies offer a deficit outlook of first-generation college students, and in my first motivation, I move away from this perspective. First-generation college students do face numerous unique challenges within higher education that offer opportunities for research and interventions to improve their enrollment, retention, and overall success in disciplines like engineering. However, they are also agentic individuals capable of acting on their environment (second motive) and I demonstrate this agentic capability throughout my three dissertation studies. Lastly, the work presented in this dissertation focuses on first-generation college students' agency through a psychological perspective, which offers a new approach to understanding identity development (motive three).

1.2 First-Generation College Students in Higher Education

First-generation college students come from a family "where neither parent had more than a high-school education" (Pascarella, Pierson, Wolniak, & Terenzini, 2004, p. 249; U.S. Department of Education, 2001). Another study has described first-generation college students as students coming from low-income households who are the "first in their families to pursue a post-secondary education" (Chen, 2005; Pike & Kuh, 2005; Terenzini, Springer, Yaeger, Pascarella, & Nora, 1996, p. 1). While a continuing-generation college student is a student who reported having at least one parent who completed post-secondary education (i.e., associate's degree, college graduate, etc.; Saenz et al., 2007). The designation of first-generation college student often varies. Whitley, Benson, and Wesaw (2018) found that only 73% of U.S. institutions had a formal definition for the first-generation college student categorization, while formal definitions varied by institutions about 56% of institutions surveyed identified first-generation college students as "neither parent or guardian hav[ing] a four-year college degree" (p. 7).

Toutkoushian, May-Trifiletti, and Clayton's (2019) recent study found the college completion rates decreased as students' parental level of education was less than a bachelor's degree, although, this study was not contextualized to engineering or STEM students. Given the findings from Whitley et al. (2018) and Toutkoushian et al. (2019), I identify first-generation college students as individuals whose parent(s)/guardian(s) do not hold a bachelor's degree. Additionally, reports have acknowledged that *often* first-generation college students come from low-socioeconomic backgrounds, evaluated through free-reduced lunch program or Pell Grant eligibility, and are from racial/ethnically diverse backgrounds (Cahalan, Perna, Yamashita, Wright-Kim, & Jiang, 2019; Delisle, 2017; Engle & Tinto, 2008; Saenz et al., 2007; Snyder, de Brey, & Dillow, 2019; U.S. Department of Education, 2001). I acknowledge the current debate regarding the limitation of using Pell grant eligibility as a proxy. An example given by Delisle (2017) is that some low-income students do not apply for Pell grants or are not made eligible due to defaulting on loans. Similarly, arguments have been made that free and reduced-price lunch (FRPL) as a proxy for low-socioeconomic status is also an imperfect measure; nevertheless, Domina et al. (2018) state FRPL "data appear to capture additional aspects of disadvantage not captured by IRS income measures" (p. 545). Using proxies such as free and reduced-price lunch or Pell grant eligibility, while imperfect, still helps explain systemic educational disadvantages. My literature will include studies that used these proxies to understand first-generation college students' experiences.

I explore one group of ethnic minority students who are overwhelmingly represented in the first-generation college student categorization in Chapter 5 of this dissertation, Latinas. Some scholars emphasize the title of low-SES when talking about first-generation college students (see Engle and Tinto, 2008; Smith and Lucena, 2016), I choose to state first-generation college students for the sake of brevity with the acknowledgment that an overwhelmingly large portion of students who are first-generation college students are also of low-SES. Additionally, empirical research has found that even after controlling for socioeconomic status, age, sex, race/ethnicity, and institution type, the "first-generation status appears to be a disadvantage throughout postsecondary education" when predicting degree attainment (U.S. Department of Education & National Center for Education Statistics, 2001, p. 26). One apparent reasoning for the finding by the U.S. Department of Education and National Center for Education Statistics could be that being a first-generation college student is systematically tied to being low-income. Additionally, an overwhelming majority of racially/ethnically diverse students are who housed within these intersecting categories.

First-generation college students are often framed in a deficit perspective; that is, lacking capital or assets that are necessary and valuable in the academy (Pascarella et al., 2004; Terenzini et al., 1996; U.S. Department of Education. National Center for Education Statistics, 2001). Conversely, other studies, taking an asset-based approach, examined the types of social capital first-generation college students utilized to navigate into and through engineering (Martin et al., 2014; Trenor et al., 2008), decisions/motivations for pursuing an engineering degree (Dennis et al., 2005; Strutz, 2012), and the benefits of "fictive kin" towards supporting their persistence (Simmons & Martin, 2014). Smith and Lucena (2016) described first-generation college students not merely as invisible minorities, but rather as invisible innovators, further declaring, by valuing their funds of knowledge as equally valuable knowledge in engineering, these students' can be viewed as legitimate creators of knowledge. My research takes this asset-based perspective advanced by scholars Smith, Lucena, Martin Trenor, and others by situating first-generation college students as active agents of their learning, identity development, and as capable thinkers and knowers of engineering.

1.3 First- Generation College Students in Engineering Understood through an Asset-Based Perspective

Engineering education studies of first-generation college students have moved away from highlighting deficit paradigms and have focused more on how this population navigates into and through engineering. Specifically, Martin Trenor and colleagues (2014) investigated the types of social capital, defined as "resources accrued through social networks" available to first-generation college students and non-first-generation college students (p. 822). Their findings in this study helped debunk a common misconception of first-generation college students, that they lack resources or social capital in engineering, given that this population reported accessing similar resources than their continuing-generation college student peers (Martin et al., 2014). Another study by the same author revealed that first-generation college students more often reported "going with the flow" and being self-directed in seeking information about engineering once an engineering career was suggested to them (Martin Trenor, 2009). Smith and Lucena (2016) described first-generation college students not merely as invisible minorities, but rather as *invisible innovators*, further declaring, by valuing their funds of knowledge as equally valuable knowledge in engineering, these students' can be viewed as legitimate creators of knowledge. Often, first-generation college students come from backgrounds where they cannot afford or have the option to attend summer engineering camps and instead are working in manual or skilled labor venues (Smith & Lucena, 2016b). By capitalizing on students' funds of knowledge, Smith and Lucena (2016) argued that first-generation college students could overcome feelings of belonging uncertainty and subsequently legitimize their lived experiences as sources of knowledge systems in engineering.

In my research, I have taken a more in-depth look at the unique and valuable attitudes, beliefs, and mindsets first-generation college students bring to engineering. In prior work, I have shown that first-generation college students on average have higher career interests in inventing/designing things, developing new knowledge and skills, applying math and science, and supervising others when compared to continuing-generation college students (Verdín & Godwin, 2015). In another study using data of first-year engineering students, first-generation college students had, on average, significantly higher engineering and mathematics identity beliefs than their continuing-generation peers (Verdín & Godwin, 2017a). Specifically, on average, first-generation college students had statistically significantly greater interest and beliefs in their capabilities to perform well and understand engineering and mathematics than their continuing-generation college student peers (Verdín & Godwin, 2017a). In another study, women who were first-generation college students were both interested in engineering and received recognition as someone that can do engineering, and these factors supported their identity development. In contrast, women continuing-generation college students reported lower levels of interest in engineering (Verdín, Godwin, Kirn, Benson, & Potvin, 2019).

Additionally, seeing oneself as an engineering type of person supported feelings of belonging in both the discipline and the classroom setting (Verdín, Godwin, Kirn, Benson, & Potvin, 2018b). First-generation college students' also had a higher self-reported interest in engineering compared to their counterparts (Verdín et al., 2019). Interest has been described as an essential motivating behavior for persistence and engagement (Deci, 1992; Renninger, Hidi, & Krapp, 2014). In the same study by Verdín et al. (2019), I found that women first-generation college students' beliefs in their capabilities to perform well in engineering strongly supported their grit perseverance of effort. Grit perseverance of effort in a study by Choi et al. (2017) was a significant predictor of one- and two-year engineering retention, even after controlling for mathematics grades.

Boone and Kirn (2016) investigated two domains of belongingness, belonging in the engineering classroom and belonging in the engineering major for first-generation college students with two or more years of engineering course work. They found that compared to their counterparts, first-generation college students were more likely to feel a sense of belonging in the classroom and their engineering major. Boone and Kirn's (2016) study was conducted at a Southwestern land-grant institution with a "higher than normal percentage" of first-generation college student enrollment (p. 18). Perhaps the environmental setting of being at an institution with a higher enrollment of first-generation college students allowed these students to see more people like them in their engineering majors. Taken together, these studies help shape a different narrative of first-generation college students, a narrative focused on the strengths they bring to engineering rather than what they lack.

1.4 Latinas, First-Generation College Students in Engineering

First-generation college students live in intersecting identities. I have chosen to focus on Latinas, first-generation college students in the final study of this dissertation, because I can more precisely speak on behalf of *one* portion of the population using their stories rather than speaking to the experiences of all. Studies suggest that first-generation college students are "more likely to be" Latino/a (Engle, Bermeo, & O'Brien, 2006, p. 16). Data taken from the Multi-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD), illustrated no persistence gap between Latinos and Latinas. However, the number of Latinas entering the field of engineering are quite low (Camacho & Lord, 2013). Likewise, a report generated from the National Science Foundation indicated that in 2012, only 37% of Latinas in college intended to major in a given STEM field. While in the 2011-2012 academic year, Latinas represented only 8% of all women who received a bachelor's degree in STEM, compared to 61% of White women, 14% of Asian women, and 9% of African American women (*Excelencia* in Education, 2015). A shared misconception in engineering is that retention is the major obstacle students need to overcome; the MIDFIELD dataset has proven otherwise. Camacho and Lord (2013) hypothesized that the a high persistence rate of Latino/as may be unique to the field of engineering or the type of students that choose engineering in college might already have higher proclivity towards successful persistence. For these reasons, (i.e., shifting in demographics, low numbers of Latinas in engineering, and higher proclivity towards successful persistence), I choose to focus one of my studies on Latina, first-generation college students.

Latinas, first-generation college students, live between two social systems, often two languages, two cultures, Anzaldúa (2012), a Chicana feminist scholar, wrote that "living in the borderlands produces knowledge by being within a system while also retaining the knowledge of an outsider who comes from outside the system"— an outsider within (p. 34). Being a Latina, first-generation college student in engineering, a white, male-dominated field means holding multiple layers of being an outsider within. It requires that these women hold multiple social perspectives while "simultaneously maintaining a center that revolves around fighting against forms of oppression" (Anzaldúa, 2012, p. 34). Latinas face what, Ong and colleagues (2011) call, the "double bind" —or "unique challenges minority women faced as they simultaneously experienced sexism and racism in their STEM careers" (p. 175). Ignoring students' identities (i.e., first-generation college students, race/ethnic groups, and gender) serves to maintain their otherness in engineering as opposed to equally valued members of the engineering profession. Likewise, Torres, Howard-Hamilton, and Cooper (2003), who focus on students' identity development in higher education, acknowledge that "attitudes about differences are influenced by how students make meaning of their own race and ethnicity" (p. 2). Thus Torres et al. (2003) declared that understanding the similarities and differences from one diverse group of students helps create better dialogue. Therefore, I seek to understand how Latinas, first-generation college students' multiple identities are negotiated in engineering education. Paying attention to students who live at the intersection of first-generation college student status, women, and ethnic minorities, I can provide a more thorough representation of a group of first-generation college students rather than generalizing to all males, females, racial/ethnic groups. While there is diversity even within the Latino/a culture, "many Latino/a are steeped in cultures that are significantly different from both the culture of their public schools and the culture taught by those schools" (Sampson, 2003, p. 5). In engineering, cultural differences often affect students who live at the margins of the prototypical white masculine normativity; this outcome is evidenced by the low representation of ethnic minorities, women, and those who live at the intersection of both. Thus I use study 3 (Chapter 5) to move away from the color-blind epistemology that serves to ignore differences and the historical, social, and cultural trends that privilege particular groups or ways of being (Bonilla-Silva, 2003).

1.5 The Importance of Seeing Oneself as an Engineer

Engineering culture is a powerful influencer that shapes who students become. The culture of engineering … "is not simply training in a prescribed set of appropriate, academic courses, but is enculturation into a well-established system of practices, meanings, and beliefs" (Tonso, 1996, p. 218). Engineering is a community of practice where students aspiring to become members must acquire the cultural norms, values, and behaviors appropriate for this community. Such norms may encompass students' knowing what it takes to act and be recognized as a competent member of the community (Lave & Wenger, 1991; Wenger, 2000). Competence is one aspect of enculturating within a community of practice. Students' enculturation into the engineering community of practice requires that educators understand how students associate with, withdraw from, or negotiate the cultural norms of this community.

Once in an engineering community of practice, students begin to form their identities as engineers. These identities are "important outcomes of participation in communities of practice"

(Holland, Lachicotte, Skinner, & Cain, 1998, p. 57). One way of understanding identity development is as a construction process, that is, "identity construction is the process of thinking about oneself as an engineer, performing an engineer self, and ultimately being thought of as an engineer" (Tonso, 2006, pp. 273–274). Additionally, identity is shaped by context and is, thus, intimately tied to learning within the engineering classroom (Varelas, 2012). Lave and Wenger (1991) posit that when individuals' location in their community of practice changes from peripheral to full participation, this change supports the development of identities. Participation in an engineering community of practice not only supports the development of students' identity, it also means that students are not entirely free to develop any type of engineering identity, rather they are guided by "larger and more pervasive meanings of [engineering] identity derived from sociohistorical legacies of [engineering]; and historical and political meanings of being" an underrepresented student (Carlone & Johnson, 2007, p. 1192). It is equally important to know who students are expected to be, that is, how are traditional engineering practices are emphasizing a certain way of being that may promote particular identity development differentially for diverse students.

Identity development, or the belief of seeing oneself as someone that can do engineering, has important, practical outcomes. Identity development supports students' future commitments to the engineering field, where students who were further along in their engineering degrees demonstrate more solidified engineering identities (Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008; Tonso, 2006). The process of learning to participate in a community fosters an identity development in the discipline. Learning is an ongoing process of participating in a community of practice, and becoming a member involves taking on roles, behaviors, and attitudes that are defined and shared within such community (Allie et al., 2009; Burke & Stets, 2000; Wenger, 1998, 2000). Allie and colleagues (2009) hypothesized that a lack of integration among existing identities and a new engineering identity can lead to poor academic performance or can lead to opting out of a career in engineering. Educational success involves integration into the engineering culture, a process that consists of identifying as someone that can do or become an engineer (Foor, Walden, & Trytten, 2007). Identifying as an engineer or the belief of seeing oneself as someone that can do engineering has significance as it positions individuals as members of the engineering community of practice by prompting students to evaluate their (in)congruence with the field (Benedict, Verdín, Baker, Godwin, & Thielmeyer, 2018; Jorgenson, 2002a; Tonso, 2006; Walden & Foor, 2008), evokes a sense of belonging (Verdín & Godwin, 2018b; Verdín, Godwin, Kirn, et al., 2018b; Wilson, Bell, Jones, & Hansen, 2010), and helps inform persistence (Jones, Ruff, & Paretti, 2013; Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Patrick, Borrego, & Prybutok, 2018; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009)

Other studies have found that students who saw themselves as physics, mathematics, or broadly STEM, type of people were more likely to choose to major in engineering (Cribbs, Cass, Hazari, Sadler, & Sonnert, 2016; Godwin, Potvin, Hazari, & Lock, 2016; Verdín, Godwin, Sonnert, & Sadler, 2018) and more likely to choose an engineering industry career (Rohde et al., 2018; Verdín & Godwin, 2017a). Specifically, Cass and colleagues (2011) found that mathematics identity significantly predicted students' choice of an engineering career, even after controlling for background factors (i.e., parents' level of education) and SAT/ACT math scores. Taken together, I conclude that developing an engineering identity or seeing oneself as a STEM-type of person has important implications for students' trajectories into and through engineering.

Often, students are implicitly expected to choose between one aspect of who they are versus what it means to be an engineer. Matusovich and colleagues (2010) affirm this idea by drawing awareness to a disconnect between students' personal identities (aspects of individuals that make them unique) and engineering identity and emphasized the need for these types of identities to be associated throughout the students engineering pathway. It is important to know who students are expected to be; that is, enculturation into an engineering community of practice often requires that educators understand how students associate with, withdraw from, or negotiate the cultural norms of the community and their identities.

A key part of identity development and negotiation is the interplay between structures (e.g., engineering culture) and agency. Agency, in a broad perspective, is "people's beliefs about their capabilities to exercise control over events that affect their lives" (Bandura, 1989, p.1175), which encompass an individuals' intention and their capability to execute that intention and produce change from their actions (Giddens, 1984). These agentic behaviors are important in understanding identity development; that is, agency is intimately connected to the leveraging and development of an identity (Basu, Calabrese Barton, Clairmont, & Locke, 2009). Likewise, individuals display agency when constructing their identities; however, this construction process occurs within contextual constraints (i.e., communities of practice and/or sociohistorical legacies; Schwartz, Luyckx, & Vignoles, 2011).

The framework used throughout this dissertation is critical engineering agency. This framework utilizes multiple disciplinary role identities along with students' agency and is adapted from the critical science agency framework developed by Basu and Barton (Basu, 2008; Basu & Calabrese Barton, 2009, 2010; Basu et al., 2009) and critical mathematics agency framework developed by Turner (2003). In this latter work, while agency may be an expression of identity, critical science agency simultaneously incorporates expressing identity (through actions) that are relevant to one's world and critical (questioning) of the social and cultural structures in place. Other prior research has focused on the identity-agency relationship (i.e., how associations impact how we act and how we act, changes how we author ourselves; Sfard & Prusak, 2005; Boaler & Greeno, 2000) and on the structure-agency relationship (i.e., how cultural and social structures impact how we act and how we can change structures through our actions; Calabrese Barton, Tan, & Rivet, 2008; Varelas, 2012; Varelas, Settlage, & Mensah, 2015). While this prior work takes an in-the-moment approach to examining the changing relationships between identity, actions, and structures, my work using critical engineering agency takes a broader approach to examining how identity and agency beliefs can influence first-generation college students' engineering pathways.

1.6 Towards an Understanding of Identity for First-Generation College Students

First-generation college students' disciplinary role identities (i.e., engineering identity, physics identity, and mathematics identity) are closely associated with agency and learning. "Learning is ... a process of coming to be, of forging identities in activity ... [learners] are becoming certain sorts of subjects with certain ways of participating in the world" (Brickhouse et al., 2000, p. 443). Disciplinary role identities are formed by both the product and byproduct of activities where students gain interest, beliefs about performing well and understanding the disciplinary content, and through recognition by others (Cribbs et al., 2015; Godwin et al., 2016; Hazari et al., 2010). These identities are not an "a priori constituent of activity but [are] something that is made and remade as activities unfold and when individuals participate in multiple activity systems" (Roth & Barton, 2004, p. 16). First-generation college students' disciplinary role identities are as much an outcome of their actions (i.e., personal agency) as environmental factors. Therefore, I ground my work on first-generation college students' lived experiences in a triadic model of reciprocal causation (Bandura, 1986) where students' personal factors (e.g., cognitive abilities, self-efficacy beliefs, and attitudes), behavioral factors (e.g., performance and skills), and environmental factors (e.g., social-cultural setting) play a role in enacting agency and developing disciplinary identities.

In the first section of my dissertation, I expand the critical engineering agency framework to encompass multiple identities, and personal agency as conceptualized by psychologist Albert Bandura, using constructs of intentionality, forethought, self-reactiveness, and self-reflectiveness. In Chapter 2, I provide an overview of the critical engineering agency framework and how I incorporate constructs of personal agency. By expanding the framework, I can further understand how first-generation college students' multiple identities and agency interact in the engineering community of practice. In chapter 3, I describe the process of validating a scale to measure personal agency constructs. In Chapter 4, I use the personal agency scale to understand how first-generation college students develop an engineering identity and seek to make a difference in the world (i.e., enact critical engineering agency). The second section of my dissertation (Chapter 5) focuses on understanding how Latina, first-generation college students integrate and negotiate their multiple identities in the culture of engineering. Often, to be counted as an engineer, one must "look like an engineer, talk like an engineer, and act like an engineer" (Jorgenson, 2002, p. 355). This dissertation research focuses on understanding how students who live at the intersection of ethnic minority, female, and a first-generation college student negotiate who they are for who they want to become within the context of engineering.

1.7 Mixed Method Design

For this dissertation, I use a mixed method study design. A mixed method study involves the collection of both quantitative (close-ended) and qualitative (open-ended) data to answer the research questions (Creswell, 2014). Mixed methods involves the analysis of both forms of data, rigor is required for both forms of data collection (e.g., "adequate sampling, sources of information, data analysis"), and both forms of data are integrated in the design analysis "through merging the data, connecting the data, or embedding the data" (Creswell, 2014, p. 217).

Creswell and Plano Clark (2007) identify several types of mixed method studies. In this dissertation, I used an explanatory sequential mixed method design. Creswell (2012) notes that an explanatory sequential design tends to appeal to researchers who have a stronger quantitative background because it emphasizes the ability of quantitative methods to answer generalizable research questions first and uses qualitative data to give these results depth. Since most of my work on first-generation college students have been quantitative, I found this design method appealing. An explanatory sequential mixed method design is a two-phase project, where phase 1 collects quantitative data, analyzes the results, then uses the results to build on the second phase, the qualitative part of the study, as seen in Figure 1.1 (Creswell, 2014). Typically in this mixed method design approach, the quantitative data collected is used to purposefully sample participants; the research questions in the qualitative phase are meant to support or help examine in more detail the results from the quantitative phase (Creswell, 2014).

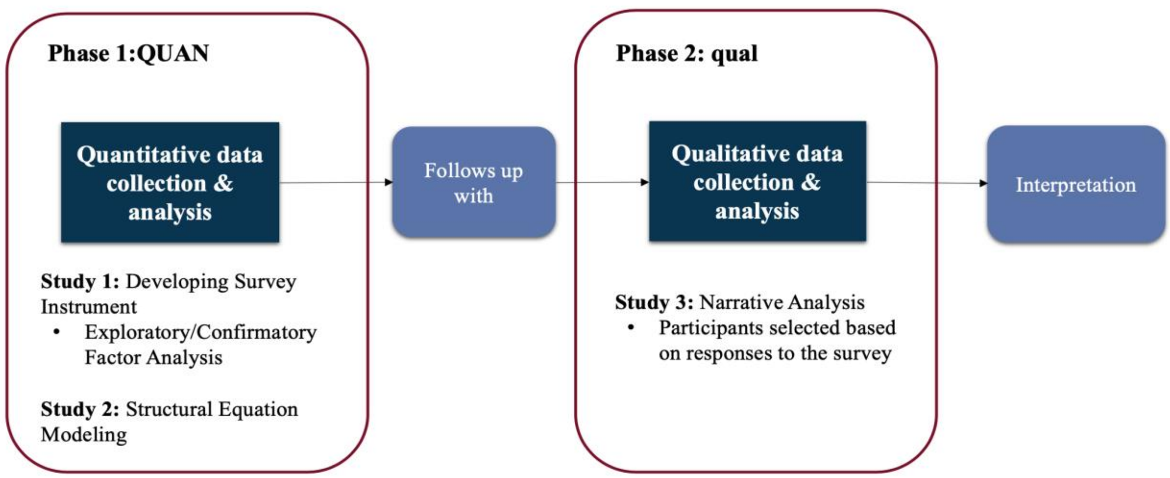

Figure 1.1. Explanatory Sequential Mixed Method Design

1.8 Philosophical Worldview

Creswell (2009) describes a philosophical worldview as the assumptions brought forth by the researcher to the research design, where worldview is the "basic set of beliefs that guide action" (p. 6). There are four commonly discussed worldviews or paradigms a researcher can adhere to (Creswell, 2014; Creswell & Poth, 2017; Denzin & Lincoln, 1994). In this dissertation proposal, I will use pragmatic, constructivist, and transformative paradigms. Where a pragmatic worldview is not committed to "one system of philosophy and reality," instead, it draws "liberally from both quantitative and qualitative assumptions" (Creswell, 2014, p. 11). A constructivism paradigm allows for the co-construction of meaning between the research and participant as they are interpreting it. Transformative philosophical worldview centers on the needs of marginalized individuals or groups in society, placing importance on the lives and experiences of these diverse groups of individuals. The approach of taking on multiple paradigms is called crystallization. Where crystallization allows for qualitative researchers to "cast a wide net" of paradigms to maintain achieve richness and diversity of perspective while preserving coherence and clarity (Ellingson, 2009, p. 73). A mixed method design requires the collection of multiple forms of data, which in turn requires the application of diverse paradigms.

1.9 Significance of the Three Studies

The three studies offer novel ways of understanding a group of underrepresented students (i.e., first-generation college students and Latina, first-generation college students) using an asset-based approach. Study 1 is significant in that it develops personal agency measurement items that can be used to understand the cognitive processes of performing agentic actions. These personal agency items can then be used to inform other areas of research, such as disciplinary role identities. Study 2 uses the personal agency scale to understand how it informs the development of first-generation college students' disciplinary role identities and beliefs about making a difference in the world through engineering. Both studies 1 and 2 expand the critical engineering agency to include a cognitive understanding of agency and apply the framework in a novel way. Study 3 seeks to understand how one Latina, first-generation college student negotiated her multiple identities as she authored an identity as an engineer over time.

1.10 Positionality of the Researcher

A positionality statement is an acknowledgment that the researchers' interpretation of the data is "based on [their] cultural, social, gender, class, and personal politics" brought with them to the research study (Creswell & Poth, 2017, p. 44). Berger (2015) wrote about three major ways a researchers' position impacts their study: 1) access to the field, 2) shape the nature of the researcher-researched relationship, and 3) researchers' worldview and background affect how they "construct the world, use language, pose questions, and choose the lens for filtering the information gathered from participants and make meaning of it" (p. 220). Whereas access to the field entails having a shared or unshared connection with participants, e.g., researcher and participants could have grown up in similar neighborhoods, thus creating a link and subsequently shaping their relationship. Understanding who the researcher is and how their views develop their study design, method, data collection, and data analysis enhances the quality of the research (Berger, 2015) and secures research's trustworthiness (Shenton, 2004).

I am a Latina (Mexican-American to be exact) who grew up in a low-income community; I am the first in my family to attend college, and I studied engineering. This positionality influences how I construct my research methods, how I examine data, and how I embody the nature of my researcher-researched relationship. My motivation to conduct an asset-based study of first-generation college students was driven by the overwhelming deficit view of this population. As a low-income, first-generation college student, I knew the scholarship depicting my community was not a just representation of the diverse experiences of this population. I sought to change this deficit perspective through my research. First, I was driven to demonstrate that despite structural inequalities in the educational system, first-generation college students pushed through or enact their agency and enroll in universities. Thus, my research shifts the subject position placed on this community to an asset-based perspective.

1.11 Format of Dissertation

This dissertation is written in a three-study format. Each study stands alone, yet they help inform how first-generation college students come to see themselves as engineers and enact their critical engineering agency. This dissertation will include six chapters. Chapter 1 serves as the introduction providing context to the purpose of the three studies. Chapter 2 provides a holistic overview of the theoretical framework used in all three studies. Chapters 3-5 will comprise of individual studies, all with their own research design, method, results, discussion, and conclusions. A summary of the three studies is provided below.

1.11.1 Chapter 3 Study 1: Development of a Measurement Scale for Personal Agency

This study grounds first-generation college students lived experiences in a triadic model of reciprocal causation where students' personal factors (e.g., cognitive abilities, self-efficacy beliefs, and attitudes), behavioral factors (e.g., performance and skills), and environmental factors (e.g., social-cultural setting) play a role in enacting their agency (Bandura, 2001, 2002, 2005). Personal agency allows educators to acknowledge that students are authors of their actions (Côté & Levine, 2014), and their actions, when targeted in the context of engineering, have engineering identity-forming outcomes. This study identifies how cognitive processes of personal agency (i.e., forethought, intention, reactivity, and reflection) shape a students' agentic behavior. This study provides evidence to prove the following hypotheses,

H1. A revised, reliable measure of personal agency, using Bandura's four constructs of agency (i.e., intentionality, forethought, self-reactiveness, self-reflectiveness), can be achieved with engineering students.

H2. First-year engineering students will conceptually distinguish between the four elements of personal agency, i.e., forethought, intentionality, self-reactiveness, self-reflectiveness.

1.11.2 Chapter 4 Study 2: Enacting Agency: How First-Generation College Students' Personal Agency Supports their Disciplinary Identity Development and Aspirations of Making a Difference

First-generation college students' development of a disciplinary identity is a result of their high school's exposure to their curricula and their experiences in and outside the classroom. Before post-secondary education, most students have little to no direct engineering experience or meaningful exposure to engineering practice (National Academy of Engineering and National Research Council, 2009). Often high school students who intend to major in a STEM field take the same mathematics and science courses in their pre-college education, regardless of future intended major. A lack of direct engineering experience makes the development of an engineering identity before college more difficult compared to other science and mathematics disciplines, such as biology or chemistry, which offer at least some direct, explicit experiences for students in high school (Fleming et al., 2006; Marra et al., 2012; Seymour et al., 1997). In this study, I examine first-generation college students who are enrolled as first-year engineering students because I sought to understand the practices and experiences that enabled peripheral participation in engineering. I understand peripheral participation through students developed interest, internal and external recognition as someone that can do engineering and through activities or practices that supported their confidence in engineering. Students develop interest, recognition, and performance/competence beliefs in activities situated in a given context, i.e., after-school environments, classrooms, museums, home activities, etc. However, first-generation college students often come from family backgrounds that make it difficult to obtain access to some of these STEM-related resources yet still find ways of participating that support their identity development. This study incrementally uncovers how first-generation college students' personal agency, as modeled in Study 1, supports their disciplinary role identities, how a mathematics and physics identity supports the development of engineering identity, and how their personal agency and engineering identity empowers students to change their environment. This study provides evidence to prove the following hypotheses,

H1. I hypothesize the concept of an engineering identity, physics identity, and mathematics identity will be supported by the latent constructs of interest, recognition, and performance/competence beliefs.

H2. A mathematics identity will support the development of a physics identity and both will inform the development of an engineering identity.

H3. Personal agency will have a direct influence on the development of students' mathematics, physics, and engineering identities.

H4. Personal agency will support first-generation college students' disposition to use engineering as a tool towards making a difference in their community or world around them (i.e., engineering agency) and, in turn, will support the development of an engineering identity.

1.11.3 Chapter 5 Study 3: "I don't fit the numbers": A Narrative Analysis of How One Latina, First-Generation College Student Authors her Identity as an Engineer

The purpose of this narrative analysis was to understand how a Latina, first-generation college student authored her engineering identity, negotiated her multiple identities as she progressed through her disciplinary program, and how agency contributed to her narrative of becoming an engineer. This study builds upon the previous study and expands our understanding of how students enact their critical engineering agency in ways that were not captured in Study 2. Narratives provide a way to "open a window onto ignored or alternative realities" (Delgado & Stefancic, 2012, p. 45). This study emphasizes that multiple identities (e.g., role, social, and personal identities) never operate as mutually exclusive. Instead, identities interact with each other depending on the situation and the salience of particular identities (Burke & Stets, 2009). It is important to include multiple identities to understand the first-generation college student population as these identities come with unique and varying lived experiences. Experiences are tied to who students are as individuals and how they position themselves and are positioned by others in the world. This study sought to answer the following research questions, RQ1. What are the experiences that shaped how a Latina, first-generation college student authored her engineering identity?

RQ2. What experiences prompted my participant to negotiate her multiple identities?

1.11.4 Chapter 6 Synthesis and Practical Strategies

The last chapter of this dissertation is a synthesis of how all the studies inform a broader understanding of first-generation college students as well as the limitations and future work. Additionally, this chapter offers practical strategies for engineering educators to support first-generation college students' agency.

2. THEORETICAL FRAMEWORK: CRITICAL ENGINEERING AGENCY

The critical engineering agency framework describes students' learning processes as (1) seeing oneself as a type of person that can do engineering, (2) using engineering, and broadly STEM, in personally and socially meaningful ways, (3) imagining and constructing a socially just and equitable world through engineering, and (4) engaging in actions that are personally and socially transformative, (Basu, Calabrese Barton, Clairmont, & Locke, 2009; Godwin, 2014; Godwin & Potvin, 2016; Godwin, Potvin, Hazari, & Lock, 2016; Turner, 2012; Turner & Font, 2003). The outcome of critical engineering agency supports students' disciplinary identity development, affords students the dispositions to alter their world using science and engineering, and effects change in students' lives and those in their community. A conceptual overview of the critical engineering agency framework is outlined in Figure 2.1.

This chapter describes the critical engineering agency framework and its multiple components. To begin, I provide an overview of the concept of agency, as many disciplines have overlapping views on how agency is operationalized. Specifically, I focus on how agency was described by Turner (2012) and Basu et al. (2009) as their critical mathematics and physics agency frameworks were instrumental for the development of critical engineering agency. Following, I discuss how agency, through the lens of Bandura's social cognitive theory, can further inform how agency is conceptualized in the critical engineering agency framework. I discuss the central tenet of authoring a disciplinary role identity and how agency plays a key role in the authorship of being a STEM type of person as conceptualized by prior work, (Carlone & Johnson, 2007; Cribbs, Hazari, Sonnert, & Sadler, 2015; Godwin et al., 2016; Hazari, Sonnert, Sadler, & Shanahan, 2010; Potvin & Hazari, 2013). I provide a conceptual extension of how disciplinary role identities are authored using the triadic model of causation outlined in social cognitive theory. Specifically, I examine how the constructs of interest, recognition, and performance/competence can be understood through personal, behavioral, and environmental factors (i.e., the triadic model of reciprocal causation). While Figure 2.1 provides a broad overview of the tenets of critical engineering agency, the sections below add more depth to how these tenets were operationalized and developed.

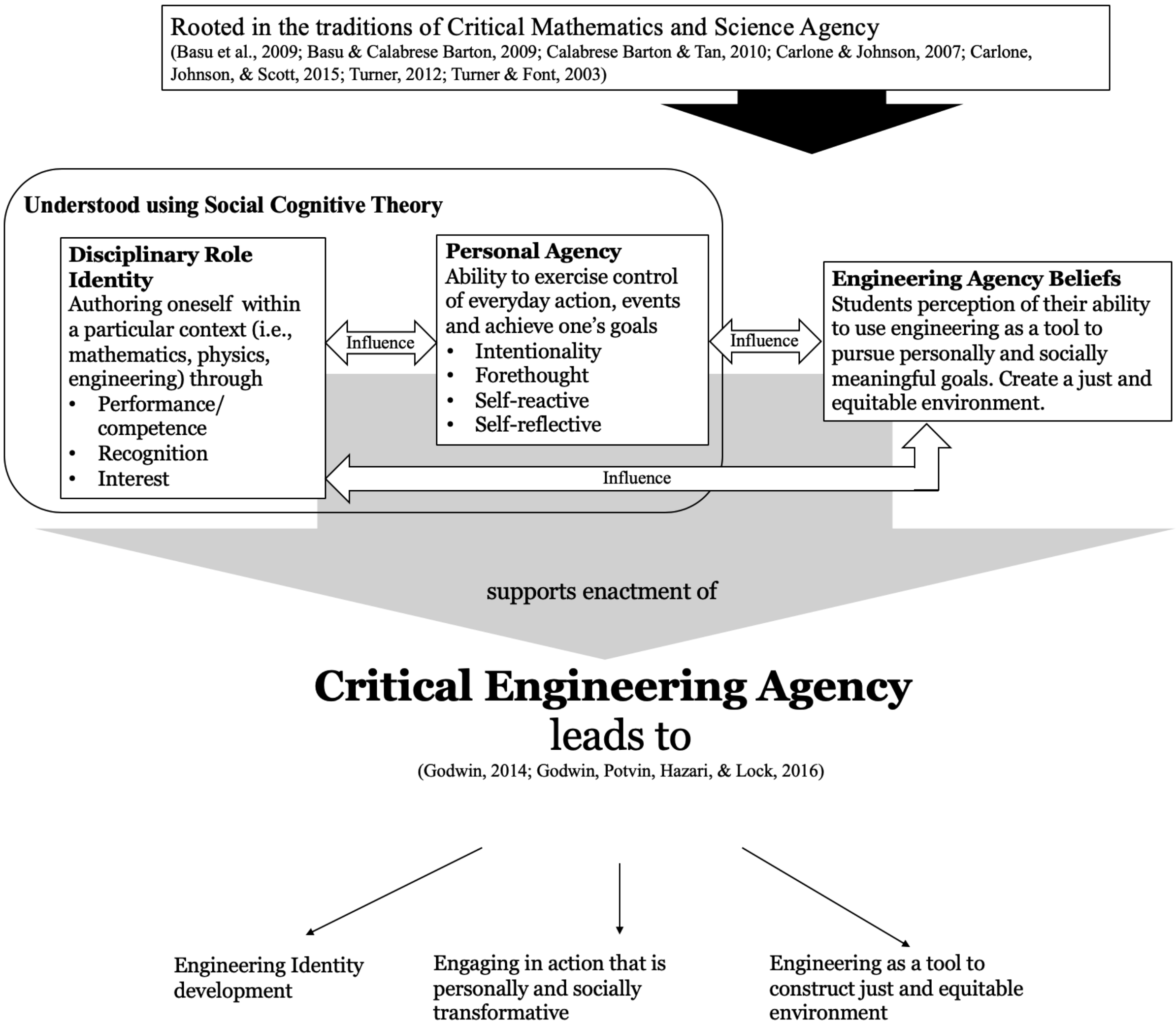

Figure 2.1. Concept Map of Critical Engineering Agency

2.1 What is Agency?

Agency, at a surface level, can be understood through associated terms such as will, purposiveness, intentionality, choice, initiative, freedom, and creativity (Emirbayer & Mische, 1998). Sen (1987), a recipient of the Nobel Prize in Economics, posits, "You could have a great deal of *freedom*, without achieving much" (p. 1, emphasis in original). Agency is the exercise or manifestation of an individual's capacity to act (Schlosser, 2015). Agency is presumed to be present in all fundamental human action; that is, every individual (actor) possess agentic (or internal behaviors) capabilities and can exercise these capabilities at any time. Agency is thought to be "the ability to exert influence on one's life" (Hitlin & Elder, 2007, p. 38). Anthony Giddens

(1984) posits that agency, while encompassing an individuals' intention, also involves the individuals' capability of acting on an intention and producing consequences (or change) from their actions (p. 9). In a psychologist perspective agency is "people's beliefs about their capabilities to exercise control over events that affect their lives" (Bandura, 1989, p. 1175) and agentic actions involve "exploring, manipulating, and influencing the environment" (Bandura, 2001, p. 4). Individuals possess varying degrees of capabilities, and in turn, they possess different perceptions of agentic potential. Agency is not removed from contextual conditions (i.e., social structures, power relations, and discourses), whereas students actively shape their surroundings, these surroundings also shape students (Eteläpelto, Vähäsantanen, Hökkä, & Paloniemi, 2013; Hitlin & Elder, 2007). In sum, agency is individual behavior and behavior through interaction between the self and society.

An individuals' agency and its interaction with society have been outlined in spaces such as anthropology (Holland et al., 1998), psychology (Bandura, 1999b, 2006, 2015; Vygotsky, 1987), life course studies (Elder, 1994; Eteläpelto et al., 2013; Hitlin & Elder, 2007), and the social sciences (Archer, 2004; Giddens, 1984). In STEM education research, where my research focuses, agency has been prominent among scholars concerned with issues of equity and social justice in-and-out of the classroom setting, specifically in areas of science education (Basu, Calabrese Barton, Clairmont, & Locke, 2009; Calabrese Barton & Tan, 2010; Carlone, Johnson, & Scott, 2015), mathematics education (Turner, 2012; Turner & Font, 2003) and engineering education (Godwin, 2014; Godwin & Potvin, 2016; Godwin et al., 2016).

A great deal of definitional overlap is found among these disciplines. The anthropological perspective situates the individual (actor) in a "historically contingent, socially enacted, culturally constructed 'worlds'" (Holland et al., 1998, p. 42). Historically contingent refers to cultural identities an individual brings with her/him to each interaction, the interaction being the social space where these cultural identities are enacted, and where culturally constructed worlds pertain to individuals figured world (e.g., classrooms). Additionally, offering a brief understanding of how individuals are situated in social structures (cultural worlds, figured worlds, sociohistorical legacies) is a preface to the use of agency in STEM education. Agency as being historically situated agrees with the social scientists positioning of agency in "structures, discourses, and power, and the ways in which socio-economic structures constrain and resource individual actions" (Eteläpelto, Vähäsantanen, Hökkä, & Paloniemi, 2013, p. 48). The anthropological perspective of agency, as described by Holland et al. (1998), is foundational to framing critical mathematics and physics agency.

I presented a broad overview of how agency has been conceptualized in mathematics and science education because I draw from these disciplines to frame my understanding of critical engineering agency. To describe the critical agency frameworks used in a STEM context, I will begin by outlining the creation of the critical subject-matter agency frameworks, i.e., critical mathematics agency, critical physics agency, and critical engineering agency. In Figure 2.2, I have outlined the sequential origins of the critical agency frameworks to provide the reader with a general, surface-level understanding of their temporal origins.

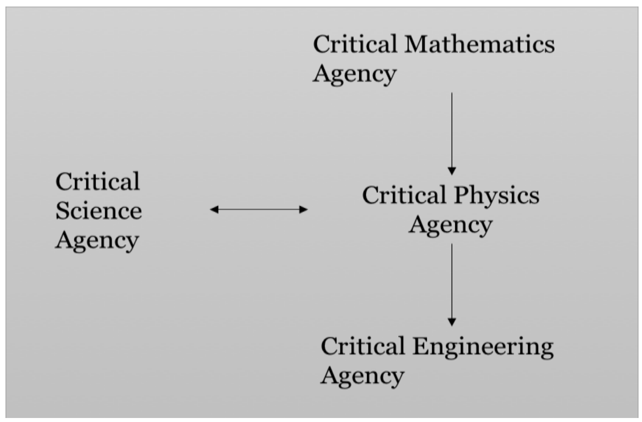

Figure 2.2. Chronological Overview of the Critical Subject-Matter Agency Frameworks

2.2 How is Agency Conceptualized in Critical Mathematics Agency?

Turner's (2003) framing of agency in critical mathematics agency was a combination of Holland's understanding of agency, its enactment in figured worlds (i.e., mathematics classroom) and critical student agency (discussed below), as a way to connect agency and social justice. Turner (2003) drew on the work of Holland and colleagues' (1998) to define agency as,

> the realized capacity of people to act upon their world and not only to know about or give personal or intersubjective significance to it … capacity is the power of people to act purposively and reflectively, in more or less complex interrelationships with one another, to reiterate and remake the world in which they live… (p. 42)

Thus, students are positioned as active participants (agents) who "act upon the world in purposeful ways, with the aim of creating, impacting, and/or transforming themselves and/or the condition of their lives" (Turner, 2003, p. 18). Whereas agency is enacted by the participation, day-to-day actions organized within the students figured world (i.e., mathematics classrooms). Students develop agency when they

> (a) consciously accept or reject the subject positions cast upon them by others,
> (b) as they identify themselves as actors with more or less influences… privilege … or power,
> (c) as they challenge or attempt to transform the norms and values that constrain their activity,
> (d) as they participate in acts that are consequential both personally and collectively, and
> (e) as they develop skills and understandings that enhance their capacity to direct their own behavior in these worlds (Turner, 2003, p. 20).

While enacting agency is not limited to large-scale protest and resistance, within the context of a mathematics classroom; agency is a subtle and daily occurrence but enacted in powerful ways. Enacting agency has been referred to as self-authoring, that is, how students' "respond to the positions cast upon them, as they answer the world, they simultaneously make meaning of the world and themselves" (Turner, 2003, p. 24). Within Turner's conceptualization of agency, enacting agency is also thought of as acts of transformational resistance and critique (Baez, 2000; Pruyn, 1999; Solorzano & Bernal, 2001). Agentive actions are "*transformational resistance* motivated and supported by a critique of oppressive conditions, ideologies, and norms, and a sense that individuals and social change is possible" (Turner, 2003, p. 26, emphasis in original).

Having this understanding of agency, Turner connected agency to social justice, casting it as critical student agency. Critical student agency, stemming from critical agency, is the "purposeful action taken by a student, or group of students, to facilitate the creation of counter-hegemonic pedagogical (i.e., educational) practices" (Pruyn, 1999, p. 4). Scholars and philosophers that have influenced Pruyn's construction of critical student agency, which is part of the construction of critical mathematics agency, include Michel Foucault, Paulo Freire, and Antonio Gramsci. From Foucault, Turner borrowed the understanding that ways of being are informally imposed on students. From Gramsci, the concepts borrowed were notions of hegemonic domination and "the understanding that hegemony can be resisted through "counter-hegemony" or the working class' transformation of cultural domination into sites of revolution and social change" (Baez, 1999, p. 192, as referenced in Pruyn, 1999). And lastly, a Freirean critical pedagogy which seeks to challenge the traditional classroom structures, where "the teacher teaches and the students are taught … the teacher knows everything and the students know nothing …" (Freire, 2000, p. 73; Pruyn, 1999). Turner's (2003) framing of agency in critical mathematics agency was a combination of Holland's agency, its enactment in figured worlds (i.e., mathematics classroom), and critical dispositions to connect agency and social justice. To conclude, agency in critical mathematics agency has roots in students' social, cultural, political, and historical positions within the education system and society.

2.3 How is Agency Conceptualized in Critical Physics Agency?

Critical physics agency appears to define agency as having two dimensions: intersectionality and behavior, taken from the work of Bandura (2001) to represent ways of "exploring, manipulating and influencing the environment" (Basu, 2008, p. 4). Agency was also defined through Holland and colleagues' (1998) classification "modifying one's environment with the aim, but not the certainty, of affecting behavior" (p. 39). And, agency was conceptualized as "giving significance to the world in purposeful ways, with the aim that students create, impact and/or transform themselves and/or the conditions they live in (Vora & Calabrese Barton (2006), p. 209, as referenced in Basu, 2008). Thus Basu (2008) framed agentic individuals in critical physics agency to include envisioning transformation and/or pursuing actions, also thought of as goal setting, to bring about change. Basu (2008) also considered a critical agency approach, similar to Turner's (2003) conception, and influenced by the work of Solórzano and Yosso, (2001), of students challenging the historical power structures of schools and/or classrooms. Grounded on these threads in agency literature, for the study critical physics agency, Basu (2008) conceptualized critical agency to represent

> a young person's desire for or action toward changes that can range from the personal to the global and contain an element of identifying and transforming historically oppressive and marginalizing power structures (p. 254).

Students' enactment of agency "involves reflection and the development of awareness, it necessitates that individuals continually examine their identities—who they are and how they change" (Basu et al., 2009, p. 360). Thinking of agency with science and through science suggested that students would

> (a) gain deep understandings of science and the processes, skills, and modes of inquiry associated with the content of science,
> (b) identify themselves as experts in one or more realms associated with science,
> (c) and use science as a context for change, such that students' identity develops, their position in the world advances, and/or students alter the world towards what they envision as more just (Basu & Calabrese Barton, 2009, p. 389)

Basu frames agency as intimately tied to the process of learning, "learning as agency offers us a way to make sense of how sociocultural stances on learning can account for issues of power" (Basu & Calabrese Barton, 2009, p. 389). In sum, agency in critical physics agency "spanned the continuum of personal, local, community, and global goals for change, transforming historically oppressive power structures" (Milne et al., 2009, p. 401). Critical agency is "intimately related to the leveraging and development of identity" (Basu et al., 2009, p. 356) to support the development of scientific literacy. There is an interaction between agency and identity in that enacting agency involves a reflective practice, and it requires that the student continually negotiate their identities-in-practice as they move towards increasing their scientific literacy and reaching their goals through science.

2.4 How is Agency Conceptualized in Critical Engineering Agency?

Within the critical engineering agency framework, agency beliefs "are focused on how students perceive their empowerment rather than on their explicit actions, as is typically the case with research on agency" (Godwin et al., 2016, p. 317). The use of agency in this framework is heavily focused on students' epistemological understandings and use of concepts within engineering. Agency is tied to the students' capabilities to shape their environment through engineering "(e.g., using their knowledge of science/engineering to design solutions for their community) and in their broader goals (e.g., pursuing a career in a service-related engineering field)" (Godwin & Potvin, 2016, p. 4). Engineering agency beliefs in this framework are closely tied to developing a critical thinking mindset about science, engineering, and what they can do for the world. Students' agency beliefs encompases "think[ing] about STEM as a way to better themselves and the world along with being a critic of themselves and science in general" (Godwin & Potvin, 2015, p. 939). The critical thinking perspective is intimately tied to engineering agency beliefs, where students become "evaluator[s] of STEM as well as become critics of themselves and the world around them through self-reflection" (Godwin, 2014, p.13). In essence, agency beliefs in this framework are based on a spectrum of how students view engineering as a way to change their world or the world at large.

2.5 Comparing the Critical Mathematics, Physics, and Engineering Agency Frameworks

The critical mathematics and physics agency frameworks were situated in the figured world of a mathematics and science/physics classroom. In Turner's framing of critical mathematics agency, identity does not play a central role. That is, identity is connected to agency, but agency remains at the forefront of the critical mathematics agency discussion. Foregrounding agency in this framework is mostly because the author intended to use students' enacted agency and mathematics as a tool for social justice. The critical mathematics agency framework aimed to nurture social justice efforts in students' communities and, through agency, use mathematics as the tool to impact one's life and the world around them. Critical mathematics agency didn't use language around acting as mathematicians or taking on the role of a mathematics type of person (identities-in-practice). While there could be a stronger connection between developing an identity and identities-in-practice in the critical mathematics agency framework, it was not the approach taken.

The critical physics agency framework "emerge[d] as the expression of identity and the strategic deployment of resources and identity" (Basu et al., 2009, p. 356). Enacting a critical physics agency was an identity shaping practice (i.e., identities-in-practice). Likewise, in the critical physics agency framework, the authors draw on the notion of students "acting like scientists" and taking on the role of a scientist or science type of person. Additionally, Turner applies the critical mathematics agency framework in a manner that students' agency is enacted, while in the critical physics agency framework, students themselves are changed through agency, which requires negotiation of identity. In Basu's framework, she heavily emphasizes identity development, while Turner's use of critical mathematics agency was centered on social justice issues.

Engineering agency beliefs are unlike the critical agency used in the mathematics context as it does not take a "purposeful action … to facilitate the creation of counter-hegemonic pedagogical (i.e., educational) practices" (Pruyn, 1999, p.4). The difference is evident in that critical engineering agency framework draws upon aspects of critical science agency as opposed to critical mathematics agency. Agency in critical science agency postulates that students gain a deep understanding of the subject matter, identify themselves as experts, use science as a context for change either within themselves or the world around them (Basu & Calabrese Barton, 2009). Similar to how agency in the critical science agency framework is heavily intertwined with identity development, so is agency in the engineering agency framework. In Godwin et al.'s (2016) explanation of agency beliefs, the conceptualization of *critical* agency, as a form of actively pressing against oppressive structures, is not explicitly connected, but there are some facets present in the conceptualization of engineering agency beliefs. I believe the work of Godwin et al. (2016) purposefully moved away from the language of critical agency to agency beliefs, possibly due to the shift away from equity and social justice issues that dominated the critical mathematics agency framework. The authors of critical engineering agency move away from *critical agency* into agency beliefs in the epistemology of subjects, i.e., science and engineering. I move critical engineering agency into a *critical agency* perspective drawing on issues around race, class, and gender into the agency construct, similar to that outlined in Turner's critical mathematics agency framework. Recall in the critical mathematics agency framework, critical agency is understood as "an awareness of how oppression operates in society, similar to the idea of informed critique from critical race theorists" (Varley Gutiérrez & Turner, 2009, p. 58). In the conceptualization of critical engineering agency while the author focuses on women in engineering, an underrepresented group, the language is not centered around critical race issues, as is the case for the mathematics and science frameworks. I choose to focus on a social justice perspective and a critical agency construct (similar to critical mathematics agency) because my population of interest falls outside of the stereotypical white normativity of engineering and navigate a system that was not created for their success. I leverage the work from both Turner and Basu, who both take approaches to agency beneficial for understanding first-generation college students and Latinas' lived experiences and how these experiences shape their engineering identity.

2.6 Personal Agency Proposed through a Social Cognitive Theory

Agency, conceptualized in the three critical agency subject-matter frameworks, is broadly understood as students' capacity to exercise control over events that affect their lives; however, the internal behaviors of *how* capacity to exercise control is exerted is not well defined in the three frameworks. Missing from the discussion of agency in the critical engineering agency framework is the internal thought processes that an individual undertakes to enact agency. I draw on the work of Albert Bandura (1986, 2001, 2006) to better understand the four cognitive facets of how an individual enacts agency while accepting and embracing the overlapping definitions of agency in sociology and cultural anthropology. Thus, holding the conception of agency as described in the critical subject-matter agency frameworks constant, in this chapter, I sought to disaggregate components that makeup agency. Specifically, I expand the conceptualization of agency in the critical engineering agency framework to include a social cognitive theory perspective of agentic behaviors.

Social cognitive theory is a learning theory derived from behaviorist and social learning frameworks (Bandura, 2005). The social cognitive theory contains elements of learning as both constructivist (i.e., emphasizing the learner as active in their construction and reorganization of knowledge) and sociocultural views (i.e., stressing that the learner is embedded within sociocultural practices of teaching and learning; Martin, 2004). There are five underlying assumptions of social cognitive theory that I discuss in this section: 1) students' learn through observation and modeling, 2) learning is an internal process, 3) the environment influences people and people affect the environment, 4) students' cognitive processes have an influence in their motivation and learning, and 5) students' learn how to regulate their behavior (Ormrod, 1998).

2.6.1 Learning through observation and modeling

Social cognitive theory proposes that most learning is fostered through observing others' performance and the consequences of those performances (Bandura, 1986, 2005). Modeling, through observation of others, is a "powerful means of transmitting values, attitudes, patterns of thought and behavior" (Bandura, 1986, p. 47). Modeling is more than imitation in that modeling has broader psychological consequences than imitation. Cognitive competencies (or the belief in one's competence) and perceived abilities are forms of learning that can be achieved through observing and modeling others. Since modeling transmits values, attitudes, patterns of thought, and behavior, it is also likely that the observer will pick-up particular cues that are favored or unfavored from the model and environmental setting.

2.6.2 Learning is an internal process

The second assumption of social cognitive theory is that learning is the process of internalizing information. Behaviorist identified learning as a change in an individual's behavior, however, in social cognitive theory, knowledge may or may not result in a change in behavior (Bandura, 1986; Ormrod, 1998).

2.6.3 The environment influences people, and people influence the environment

Social cognitive theory posits that peoples' performance, are neither solely driven by inner forces nor automatically shaped and controlled by external forces. Rather people's performance

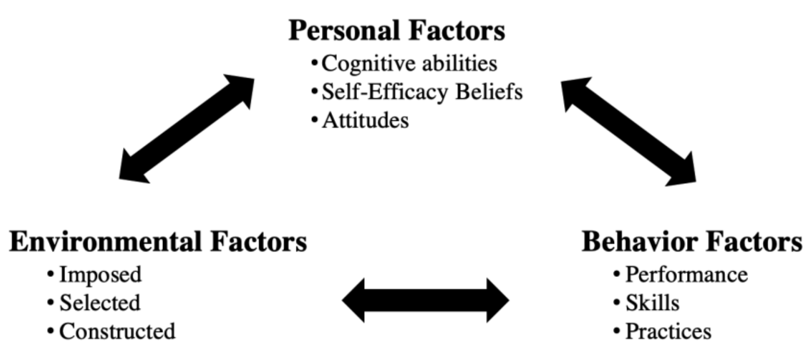

Figure 2.3. Bandura's Triadic Model of Reciprocal Causation

can be understood in terms of a model of triadic reciprocity, where people are actors, producers, and receivers of their environment (Bandura, 1986). Students' actions are a result of the interaction between personal factors, behavioral factors, and environmental factors, as seen in Figure 2.3 (Bandura, 1986). I use Bandura's triadic model of reciprocal causation to help explain how students come to see themselves as engineers, that is, how they take on the role of an engineering type of person through the interplay between personal, behavioral, and environmental factors.

Personal factors are forms of "cognized goals, quality of analytic thinking, and affective self-reactions," attitudes, self-efficacy beliefs, expected outcomes, motivation, dispositions, and language, to name a few (Bandura, 1999c, p. 191). *Behavioral factors* in social cognitive theory constitute knowledge acquisition through new ideas, practices, tendencies, or predispositions. Bandura posits that people learn through their own experiences and through observing or being influenced by others (Bandura, 1986). Therefore, behavior is understood in relation to the environment in which the individual finds him/herself. Lastly, *environmental factors* are not monolithic; there are three environmental structures distinguished in social cognitive theory, environments that are imposed, selected, and constructed (Bandura, 1999b). An imposed environment may include "situations an individual must interact with on a daily basis (e.g., neighborhood, school, work, and family)" (Meaney, Zimmermann, Lu, Martinez-Ramos, & McDonald, 2017, p. 99). Imposed environments may not allow individuals to make changes; however, individuals can interpret and react to their imposed environment. Even within imposed environments, individuals can also select their environments based on their reactions, interpretations, and resistance. Lastly, a constructed environment requires an individual to engage in and with their surroundings actively "and may often result in the acquisition of new knowledge, beliefs, and behaviors" (Meaney et al., 2017, p. 99). Each form of environment will require different levels of personal agency. Individuals are situated in society (i.e., classroom structures, cultural worlds, communities of practice, socioeconomic status, etc.). The role society plays in shaping an individual and how an individual can shape society must be acknowledged. Social cognitive theory rejects the polarization of structure and agency; the theory assumes bidirectionality between personal agency and social structures (Bandura 1986; 2005). Reciprocality denotes a joint action between causal factors (i.e., personal, behavior, and environment), but "it does not mean simultaneity of influence" (Bandura, 1986, p. 25).

2.6.4 Students' cognitive processes have an influence in their motivation and learning

Self-efficacy, the belief in one's ability to achieve their desired goals, serves as a motivating factor for learning (Bandura, 1986, 1997). Bandura notes, in a study on mathematics performance, self-efficacy beliefs "predicted interest in, and positive attitudes toward, mathematics, whereas actual mathematical ability did not" (Bandura, 1997). Self-efficacy beliefs are the most widely used aspect of social cognitive theory because an individual's sense of efficacy affects behavior in several ways, i.e., the activities they select, effort, persistence, learning, and achievement (Bandura, 1993; Ormrod, 1998).

2.6.5 Individuals learn how to regulate their behavior

The last underlying assumption of social cognitive theory is that individuals learn how to regulate their behavior. Social cognitive theory moves beyond the behaviorist view of learning, conditioning through rewards and punishment feedback processes, to include people's capacity to self-regulate (i.e., a person's ability to affect their own "thought processes, motivation, affective states, and actions through self-directed influence"; Bandura, 2005, p. 16). Bandura's more recent work, moves social cognitive theory to embrace an agentic perspective of human development, adaptation, and change (Bandura, 2001, 2002, 2005). Individuals are neither autonomous nor mechanical conveyers, but rather are contributors to "their own motivation and action within a system of triadic reciprocal causation" (Bandura, 1989, p. 1175). An individual's personal agency operates within social systems; agentic actions are therefore produced and a product of social networks (Bandura, 1997). Personal agency is achieved through the following capabilities intentional actions, forethoughtful perspective, self-reactive a form of self-regulation, and reflectivity (Bandura, 2006).

2.7 Social Cognitive Theory and Personal Agency

From a psychological perspective, personal agency is "people's beliefs about their capabilities to exercise control over events that affect their lives" (Bandura, 1989, p. 1175). In my three studies, I focus on students' personal agency with the understanding that agency influences and is influenced by environmental, personal, and behavioral factors. Personal agency manifests in students' behaviors (i.e., intentionality, forethought, self-reactiveness, and self-reflectiveness) as conceptualized by Bandura's work. In the sections that follow, I define the four properties of personal agency and describe how they interact with each other.

2.7.1 Forethought

The feature of forethought in personal agency goes beyond future-directed plans because future plans "cannot be a cause of current behavior," whereas, "through cognitive representation, visualized futures are brought into the present as current guides and motivators of behavior" (Bandura, 1986, 2006, p. 164). These foreseeable perspectives are represented symbolically to serve as motivators (Bandura, 1986). Forethought is exercised through an individual's anticipated outcomes; by projecting these anticipated outcomes over a long time, an individual's "forethoughtful perspectives provide direction, coherence, and meaning to one's life" (Bandura, 2006, p. 165). Imagined future goals serve as current motivators and propel individuals to make intentional action plans (e.g., plans to use engineering for social good or to remake one's environment).

2.7.2 Intentionality

Agency is manifested from intentional choices that lead to actions (Giddens, 1984). That is, for behavior to count as agentic, the individual must intend to take action. Giddens' (1984) view is that intentionality is characterized as an act in which the actor knows, believes, will have a particular outcome, and where knowledge is utilized by the actor to achieve the result. Intentional actions are behaviors that were chosen by the individual, they are exercised through self-influence, and are a "representation of a future course of action to be performed" (Bandura, 2001, p. 6). For an intentional act to be realized, it requires action plans and strategies (Bandura, 2001, 2006). In sum, the intentionality construct refers to a purposeful act, where a goal represents an intention grounded in self-motivators (Bandura, 2001).

2.7.3 Self-Reactiveness

Thoughts are linked to actions through the agentic behavior of self-reactiveness. Agency not only encompasses intentional capacities to "make choices and action plans, but also the ability to construct appropriate courses of action and to motivate and regulate their execution" (Bandura, 2006, p. 165). After adopting an intentional action, the student, drawing on their agency, should not wait for the necessary action to occur. Instead, through self-regulatory processes, the student links his/her plans into action (Bandura, 2006).

2.7.4 Self-Reflectiveness

Bandura (2001) stated, "The human mind is generative, creative, proactive, and reflective, not just reactive" (p. 4). Reflection allows for an evaluation of one's "motivation, value, and the meaning of their life pursuits" (Bandura, 2001, p. 10). In social cognitive theory, the capacity to self-reflect enables individuals to consider and analyze prior experiences and thought processes

(Bandura, 1986; Stajkovic, 1979). Lastly, among the four mechanisms of agency described by Bandura (2001, 2006), "none is more central or pervasive than people's beliefs in their capability to exercise some measure of control over their own functioning and over environmental events," and this is derived through reflection (p. 10). When an individual reflects on their work or prior experience, they are enhancing the importance of that work or experience. Reflection also involves "applying what we've learned to contexts beyond the original situation in which we learned something" (Costa & Kallick, 2008, p. 222). Consequently, an individuals' self-reflectiveness makes them active producers of knowledge and/or experiences, not merely consumers.

Through these constructs, mapping agency will help me empirically determine how students enact agency and how that interplays with the various disciplinary role identities in the critical engineering agency framework. Theorizing personal agency through the four cognitive behaviors better explains how an individual exercises control and makes choices based on their intention, forethought, reactivity, and reflexivity, which, in turn, helps shape the students' identity. This operationalization of personal agency is not far removed from the current discussion of agency in the critical engineering agency framework. Expanding critical engineering agency to include a social cognitive theory perspective adds to how agency can inform identity development and provide critical ways of understanding first-generation college students' participation in engineering. I have described how each component of personal agency is understood separately; in the sections that follow, I describe the four constructs of personal agency as a process and how agency functions in environmental contexts.

2.8 Process of Enacting Personal Agency

Personal agency is a multidirectional cyclical process, see Figure 2.4, wherein the achievement of a goal or outcome involves intentional actions (intentionality), forward-directed planning is done, and anticipated outcomes are foreseen (forethought), appropriate courses of action are taken (self-reactiveness), and where reflection upon action is taken (self-reflectiveness; Bandura 1989, 1999, 2001, 2006). There are bidirectional arrows to and from forethought to reflectiveness because "forethought is the product of generative and reflective ideation" (Bandura, 1986, p. 19). Bandura clarifies that "outcomes are not the characteristics of agentive acts," instead, outcomes are the consequences of agentic acts (Bandura, 2001, p. 6). Actions produced for a given purpose are the core feature of an individuals' agency. This graphical representation is a result of my interpretation of Bandura's literature on personal agency, reiterating that outcomes are consequences of agentic acts (Bandura, 2001).

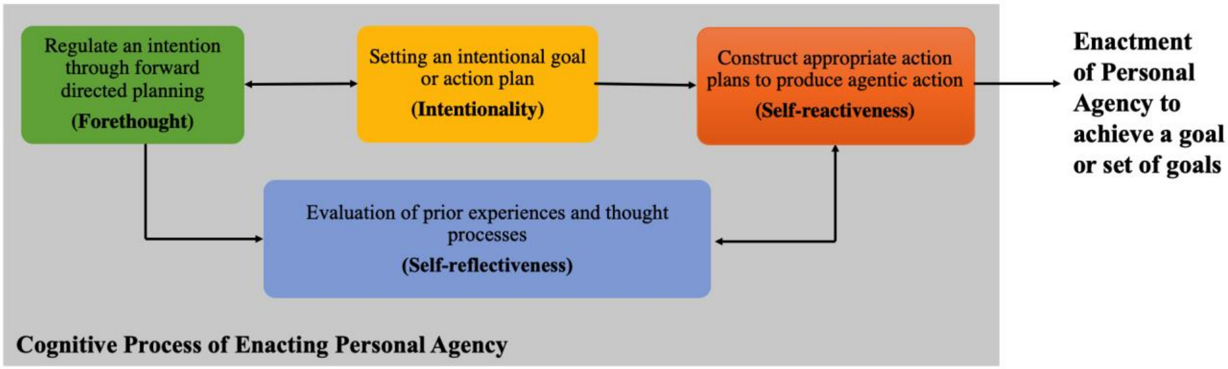

Figure 2.4. Process of Enacting One's Personal Agency

2.9 Environmental Factors and Agency

A students' personal agency operates within environments; agentic actions are therefore produced and are a product of one's environments (Bandura, 1997). Environments or structures are typically the terminologies in sociology or cultural anthropology; however, using Bandura's language of environmental factors is still congruent with structures. Likewise, Côté and Levine (2002) noted that often when sociologist and psychologist work in isolation, they identify similar processes at different levels of analysis (i.e., macro-societal level versus micro-individual level), specifically noting,

> sociologists' overly structural view can be compensated for by notions of the individual, agentic actor, and psychologists' focus on conditions in contemporary Western culture can be given a sociohistorical, cross-cultural perspective … the two perspectives can be integrated to give us a more multidimensional understanding of identity (p. 57).

Therefore, throughout my dissertation, I use environmental factors with the understanding that environments have socially structured systems and practices. Environmental factors are not monolithic; there are three environmental structures distinguished in social cognitive theory, imposed, selected, and constructed environments (Bandura, 1999b). An imposed environment may include daily situations or circumstances a student interacts with (e.g., cultural worlds, communities of practice, school settings, microaggressions, racism, sexism, etc.). Imposed environments are often created by the messages that circulate about who gets to participate in a certain field or who is recognized as a legitimate member of a community of practice. While an imposed environment, to some extent, may not allow students the capability to make changes; however, individuals do have the ability to interpret and react to their imposed environment. Even within imposed environments, individuals can also select their environments based on their reactions, interpretations, and resistance. Students' reaction, interpretations, resistance, and choices made in response to their imposed environment constitute their selected environment. Lastly, a constructed environment requires students to actively engage in and with their surroundings, through the process of engagement, students can acquire new knowledge, dispositions, and behaviors. Understanding environmental factors as consisting of three types of environments underscores the notion that students have the ability (i.e., agency) to opt into certain types of environments.

Each form of environment will require different levels of agency, and a student can shape their environment through the enactment of their agency. Additionally, the environments students navigate through have identity shaping consequences because identities are dynamically constructed through experiences (Oyserman, Elmore, & Smith, 2012). Likewise, Holland et al. (1998) discussed how identities are improvised through "the flow of activity within specific social situations, form the cultural resources at hand … the tensions between past histories that have settled …" (p. 4). These specific social situations can be understood as imposed environments with their prescribed cultural resources and past histories.

The role the environments play in shaping an individual and how an individual can shape their environment must be acknowledged. Social cognitive theory rejects the polarization of structure and agency; instead, the theory assumes bidirectionality between personal agency and social structures (Bandura 1986; 2005). Similarly, Holland et al. (1998) also rejects the dichotomy between agency and social structures and acknowledges that ""person" and "society" are alike as sites … of production and reproduction of social practice" (p. 270). Côté and Levine (2002) also affirm that individuals enact their agency in context, "they are never free from structures" rather, their agency varies in relation to their ability to utilize and transform a given structure (p. 170). Social structures understood through Gidden's structuration theory are "rules and resources, recursively implicated in the reproduction of social systems … [existing] … as memory traces … knowledgeability, and as instantiated in action" (Giddens, 1984, p. 377). Structures can be understood as “sets of mutually sustaining schemas and sets of resources that empower and constrain social action and that tend to be reproduced by that social action” (Sewell, 1992, p. 27); structures, as defined here, would be analogous to imposed environments. Sewell (1992), interpreting Gidden’s work, reconceptualizes the idea of “structures as rules” to structures as cultural schemas which are understood as patterns of interaction, expectations, reproduced over time, and knowledge of cultural schemas facilitate the capacity towards action. Resources can be considered as both human “knowledge, and emotional commitments that can be used to enhance or maintain power, including knowledge of the means of gaining, retaining, controlling, and propagating” and nonhuman, “objects, animate or inanimate, naturally occurring or manufactured, that can be used to enhance or maintain power” (Sewell, 1992, p. 9). In the context of mathematics, science, and engineering, the schemas and resources that constitute the structure of learning or participating in the discipline can be understood by the activity’s students engage. Examples of activities include the practices of talking about mathematics, science, or engineering, using the cultural artifacts of the disciplines (i.e., lab equipment, tools, mathematical formulas or equations).

While structures can be understood as constraining an individuals’ agency, Giddens (1976) declared that structures should also be conceptualized as enabling. Recognizing that knowledge is structurally formed and that individuals’ as agents are “‘knowledgeable’ and ‘enabled’ implies that those agents are capable of putting their structurally formed capacities to work in creative or innovative ways” (Sewell, 1992, p. 4). The environmental factors proposed in the triadic model can also be understood through Holland et al.’s (1998) work of figured worlds. Holland et al. (1998) situate the individual (actor) in a “historically contingent, socially enacted, culturally constructed ‘worlds’” (Holland et al., 1998, p. 42). Historically contingent refers to cultural identities an individual brings with her/him to each interaction, the interaction being the social space where these cultural identities are enacted, and where culturally constructed worlds pertain to individuals' world (e.g., classrooms). These “worlds” are socially and culturally constructed spaces of interpretation, where “particular characters and actors [students and teachers] are recognized, significance is assigned to certain acts, and particular outcomes are valued over others” (Holland et al., 1998, p.52). Students have the agency to select to engage in these “worlds” with the understanding that there are imposed ways of participating.

2.10 Personal Agency Influences Development of Disciplinary Role Identities

Students' agency and their situatedness in environmental factors influence the development of their disciplinary role identities. In this section, I first describe how I conceptualize disciplinary role identities and then illustrate how personal agency influences these identities.

2.10.1 Disciplinary Role Identities

Identities are "traits and characteristics, social relations, roles, and social group memberships that define who one is" (Oyserman et al., 2012, p. 69). Burke and Stets (2000) describe a role identity as "acting to fulfill the expectations of a role, coordinating and negotiating interaction with role partners, and manipulating the environment" to meet the needs of the role being acted out (p. 226). An individual who takes on a role identity (i.e., being an engineer) adopts the meanings and expectations that accompany the specific role "and then act[s] to represent and preserve these meanings and expectations (Burke, Stets, 2000, p. 227) and meanings are negotiated through interaction with others. Identity, in the education literature, is defined as "being recognized as a certain 'kind of person,' in a given context" (Gee, 2001, p. 99). Gee (2001) described four different identities: 1) "who I am," 2) one's position in society, 3) recognition by others through interaction, and 4) one's experiences within affinity groups. Authoring of oneself within the engineering, physics, and mathematics context is done through three interrelated constructs, interest, recognition, and performance/competence. A conceptual overview of seeing oneself as a STEM-type of person can be found in Figure 2.5.

Interest plays a key role in the framing of role identity and involves a personal desire for learning and understanding in each context (e.g., mathematics, physics, and engineering; Hazari, Sonnert, Sadler, & Shanahan, 2010). Scholars who study interest have found that learners who are interested in specific tasks "are likely to be able to self-regulate and persist to complete tasks even when they are challenged, whereas learners with little interest typically have difficulty engaging and continuing to work with tasks" (Renninger, Nieswandt, & Hidi, 2015, p. 2). Interest can be understood as a psychological state with affective and cognitive factors with focused attention on to particular content and/or an "enduring predisposition to re-engage [with] particular classes of objects, events, or ideas" (Ainley, Hidi, & Berndorff, 2002; Hidi & Renninger, 2006; Renninger & Hidi, 2002, p. 174). There are two types of interests, individual (i.e., inclination towards a specific domain or activities) and situational (i.e., triggered by environmental factors or situations) (Ainley et al., 2002; Hidi & Renninger, 2006; Renninger & Hidi, 2002). Interest is supported by students' interaction with hers/his environment; that is, a situational interest can develop into an individual interest (Renninger & Hidi, 2002). Hidi and Renninger (2006) also found that interest has a positive impact on persistence and effort, motivation, and learning in the classroom. And the development of interest is supported through interactions in the students' environment (Hidi & Renninger, 2006).

Recognition is both an external manifestation and an internal state required for identity development (Carlone & Johnson, 2007; Potvin & Hazari, 2013). Gee (2001) noted that one's identity becomes an identity when "they are recognized by myself [themselves] or others" (p. 102) in a particular context. How others perceive a person is an incomplete representation of how she/he perceives her or himself; it is also important to understand how a student internalizes these beliefs in shaping who they are and how they position themselves in the world (Godwin, Potvin, Hazari, & Lock, 2016; Potvin & Hazari, 2013).

Lastly, an individual cannot be recognized as a certain kind of person unless he/she makes visible (*performs*) their *competence* in particular domains (e.g., mathematics, physics, or engineering; Carlone & Johnson, 2007). Beliefs about performing well and understanding content material have considerable overlap with self-efficacy beliefs. Performance/competence beliefs are global or more general attitudes regarding one's capabilities. Self-efficacy beliefs are both task- and situation-specific but critical in determining how knowledge and skills are acquired (Bandura, 1989; Pajares, 1997). Self-efficacy is referred to as beliefs in an individual's capabilities to accomplish *certain* courses of action to achieve a goal or task (Bandura, 1997). "Perceived self-efficacy is an important contributor to performance accomplishments, whatever the underlying skills might be" (Bandura, 1997, p. 37). Self-efficacy is generally assessed at the microanalytic level (Pajares, 1997), for example, students can have self-efficacy beliefs in acquiring the skills to solve differential equations, balance chemical equations, or apply the laws of motion. These micro-level skills can be in harmony with students' claims towards understanding and performing well in the domains of mathematics, physics, and engineering.

Identity, as a central part of critical engineering agency, has been used to understand the outcome of students pathways' into and out of engineering. A study by Cass and colleagues (2011) found that mathematics identity, as measured by students' recognition, performance/competence, and interests beliefs, significantly predicted students choice of an engineering career, even after controlling for background factors (i.e., socioeconomic status) and SAT/ACT math scores. In a later study, mathematics and physics role identities were significant predictors for choosing an engineering career (Godwin et al., 2016). The outcomes of having critical engineering agency primes students to professional identity development, progress their status in society and/or their community, and use science and engineering concepts to change their world (Godwin, 2014; Godwin & Potvin, 2015). In a single longitudinal case study, critical engineering agency was used to examine how Sara was empowered towards developing an engineering identity, and her pathway into and out of engineering was explored (Godwin & Potvin, 2016). Another study used critical engineering agency to understand ways to foster female belongingness in the engineering classroom (i.e., community of practice) to retain this underrepresented group in engineering (Godwin & Potvin, 2015). All of these studies focused on career pathways into and out of engineering through a critical engineering agency lens.

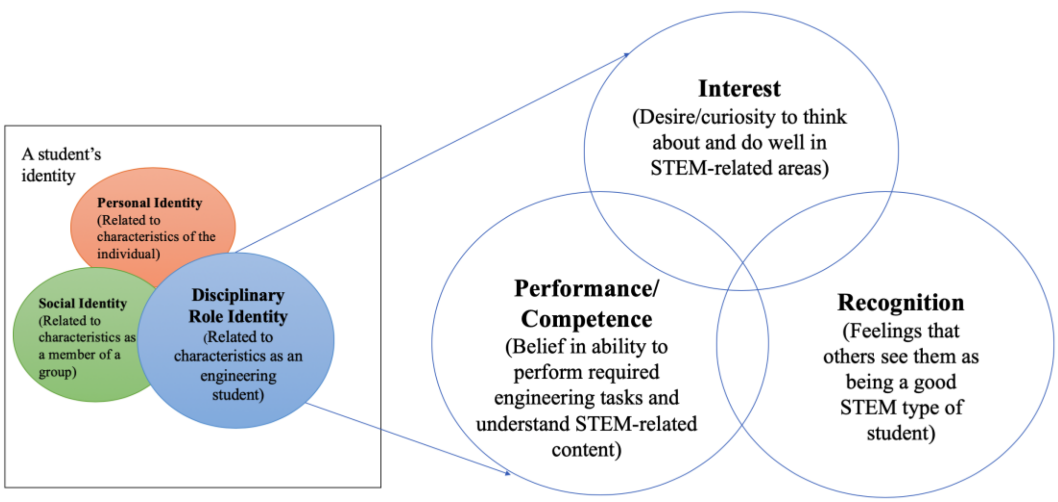

Figure 2.5. Disciplinary Role Identity adopted through the work of Godwin (2016) and Hazari and colleagues (Hazari et al., 2010). Prior modeling work found that performance and competence measures are not independent of each other (Potvin & Hazari, 2013)

2.10.2 Multiple Identities

The engineering culture shapes and reshapes who students become as identity is tied to learning in context (e.g., engineering classroom, engineering activities, etc.; Varelas, 2012). Identities never operate in a mutually exclusive manner; instead, they interact with each other through context (Burke & Stets, 2009). Social identity is concerned with an individuals' identification with a certain group (e.g., Latina, first-generation college student) and personal identity are "set of meanings that define the person as a unique individual" (Burke & Stets, 2009, p. 124), it helps define who one is. Personal identity can be distinct from social and role identity; the unique set of meanings can go beyond or are linked to one's group member and role identity (Oyserman et al., 2012). Côté and Levine (2002) argued that one's social identity is an important factor and predictor of their life situation and life chances.

Throughout my dissertation, I draw heavily on disciplinary role identities in the context of engineering, physics, and mathematics. However, I also draw attention to the fact that students bring with them other forms of identities. At any given time, an individual has multiple intersecting and contextually defined identities. These multiple identities interact with each other and, depending on the context or situation, one or a few may become more salient (Burke & Stets, 2009). Being "the only one" can often make particularly underrepresented identities more salient in an engineering context. First-generation college students live in intersecting multiple social identities, e.g., gender and racial/ethnic groups, to name a few. These identities are often marginalized and stigmatized in society and in engineering. Multiple identities are important because all forms of identities (e.g., social, personal, and role identities) never operate as mutually exclusive; rather, they interact with each other, depending on the context and the salience of particular identities within that context (Burke & Stets, 2009).

First-generation college students enter engineering with unique lived experiences, and these experiences are tied to who students are as individuals and how they position themselves and are positioned by others in the world. The dynamics of students' gender, race/ethnicity, and socioeconomic status cannot be separated and should be explored together. Additionally, "identity is a function of both external (social) and internal (agentic) factors, and that both the sociological and psychological perspectives are essential for a comprehensive understanding of the complexities of human self-definition" (Côté and Levine, 2002, p. 9). Individuals have multiple identities, the salience of their identities are invoked across or within social settings (Burke, Owens, Serpe, & Thoits, 2003). Currently, the critical engineering agency framework has utilized disciplinary role identities (i.e., interest, recognition, and performance/competence), and I am adding social identities, mainly focused on students' parental level of education and race/ethnicity, to understand the complex interactions of students' whole persons in engineering education.

2.11 Social Cognitive Theory's Triadic Model of Reciprocal Causation Helps Inform the Development of Interest, Recognition, and Performance/Competence Beliefs

Identities are created, recreated, and sustained through participation in activities and reflexivity (Brickhouse & Potter, 2001; Roth et al., 2004). Coté and Levine (2002) also affirmed that "identity is a function of both external (social) and internal (agentic) factors," both the psychological and sociological perspectives are necessary for a holistic understanding of the complexities of human self-definition (p. 9). Bandura (2008) described that agency is an important aspect of identity formation. Brickhouse (2001) also affirms that while identity focuses on the individual, it also accounts for the importance of both individual agency as well as "societal structures that constrain individual possibilities" (p. 286). Stryker (1980), used symbolic interactionism to build the theory of role identity, also affirmed that "a focus on the person without a correlative focus on social structure, or vice versa, is necessarily partial and incomplete" (p. 53).

Students' disciplinary role identities are as much an outcome of their actions (i.e., personal agency) as environmental factors. Therefore, I ground identity development in a triadic model of reciprocal causation (Bandura, 1986) where students' personal factors (e.g., cognitive abilities, self-efficacy beliefs, and attitudes), behavioral factors (e.g., performance, skills, and practices), and environmental factors (e.g., environments imposed, selected, and constructed) play a role in developing their disciplinary identities and enacting their agency. Bandura (1986) posits that people's behaviors are directed towards cognized goals and outcomes that individuals hope to realize in the future. For example, if a student has a goal (and interest) of excelling in their mathematics courses, they will enact behaviors congruent to this goal, i.e., engaging with mathematical concepts at a deeper level, joining math clubs, engaging in math activities, or talking about math more often with peers or others. Behaviors tend to be congruent with one's identity. Symbolic interactionist scholars posit that the behaviors individuals take on reflect the identity they wish to enact (Burke et al., 2003; Burke & Stets, 2009). "[I]dentities serve as behavioral guides," that is the behaviors that people engage in through their new roles or interactions are “critical elements in helping individuals define themselves as occupants of a particular position” (Burke et al., 2003, pp. 42–43). In this dissertation, I create an extension for understanding how interest, recognition, and performance/competence beliefs are developed through the social cognitive theory’s triadic model of reciprocal causation.

In the subsections that follow, I describe how the constructs of disciplinary role identities (i.e., interest, recognition, performance/competence beliefs) are developed through a triadic reciprocal causation model; an overview is outlined in Figure 2.6.

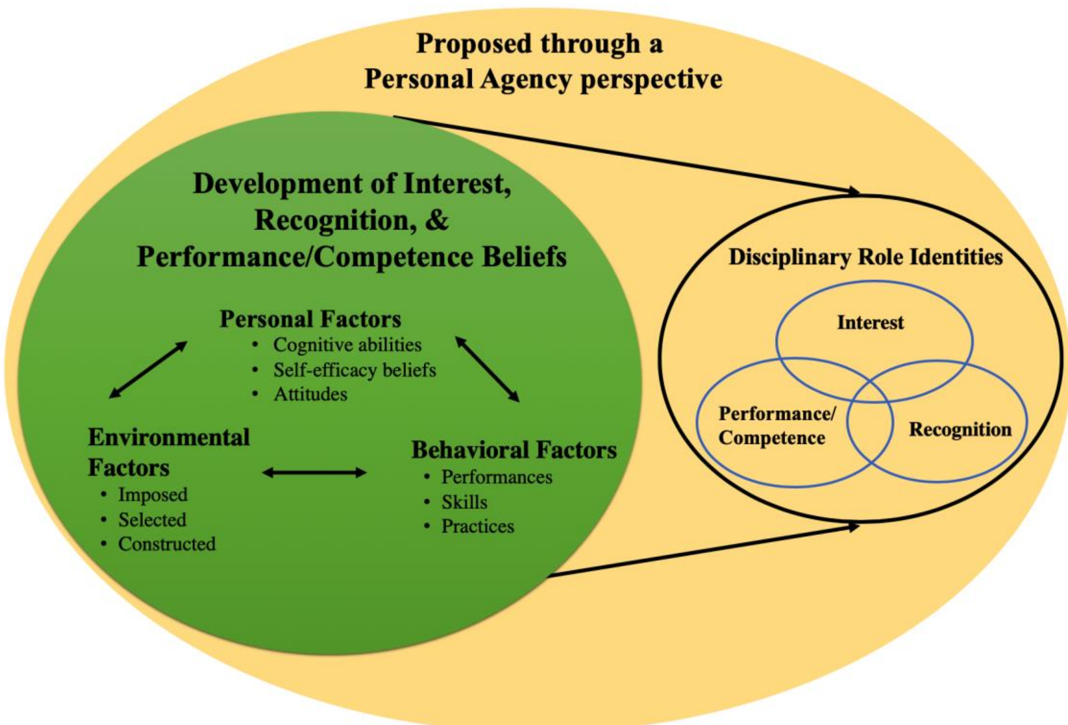

Figure 2.6. Conceptual overview of the triadic model of reciprocal causation support the development of disciplinary role identities

2.11.1 Interest Understood through the Triadic Model of Reciprocal Causation

Interest in an activity or a domain-specific topic area promotes knowledge acquisition that lays the foundation for subsequent expertise (Hidi, 1990). And the development of interest is supported through interactions in the students’ environment (Hidi, 1990; Renninger & Hidi, 2002). Interest can be understood as an individual’s predisposition towards certain activities or objects, “tends to have long-lasting effects on a person’s knowledge and values” and situational (i.e., elicited by factors in the environment “and may have only a short term effect, marginally influencing an individual’s knowledge and values”) (Ainley et al., 2002; Hidi, 1990, p. 551). However, despite the differences in effects, knowledge, and values, both individual and situational interests interact and promote each other’s development (Hidi, 1990). A developed individual interest may evoke situation-based activities or situational interest “triggered by environmental factors may evoke or contribute to the development of long-lasting” individual interest (Hidi, 1990, p. 551). In the subsequent paragraphs, I examine the environmental factors, such as family and classrooms, that contribute to students’ interest in STEM with the understanding that interest can be triggered at different points in time (i.e., elementary, middle school, and high school).

Early experiences, provided through an individual’s environment, are critical for the development of STEM interest, from a child’s early years (Ainley & Ainley, 2015; Harlan, 1996; Low, Yoon, Roberts, & Rounds, 2005), to their secondary education (George & Kaplan, 1998; Gilmartin, Li, & Aschbacher, 2006; Godwin & Potvin, 2017; Godwin, Sonnert, & Sadler, 2015; Maltese, Melki, & Wiebke, 2014; Maltese & Tai, 2011; Verdín, Godwin, Sonnert, et al., 2018). Students in grades K-12 spent approximately 18.5% of their time in formal learning environments (i.e., classrooms; LIFE Center, Stevens, Bransford, & Stevens, 2005). Thus the experiences they have out-of-school are important to consider (Dorie & Cardella, 2014). Leibham and colleagues (2005) noted that the parent to child dynamic relationship should be taken into consideration when considering interest development. Initially, parents hold the task of triggering and supporting initial interest; overtime, the child sustains the interest on their own by feeling empowered and finding personal relevance towards pursuing their interest (Leibham et al., 2005). In other words, parents can impose an environment that can support interest, and students can respond to that environment by selecting to engage in the topics. Students’ engagement with informal learning environments (i.e., out-of-school experiences) can also enrich learning in formal environments (Crowley & Galco, 2001).

Dorie and Cardella (2014) posited that even spontaneous interactions, for instance, “posing a question in the car to a parent, also allow an avenue for children of all ages to discover new knowledge and can often have long-term impacts” (p. 346). Ferry, Fouad, and Smith (2000) also found that parental encouragement in math and science (i.e., the environment constructed by students’ parents, was influential in students’ learning experiences). Camacho and Lord (2013) also talked about these spontaneous interactions that sparked interest in engineering through the voice of one of their participants, “My dad, he’s not a civil engineer … but whenever we go anywhere and drive anywhere, if he sees a bridge or a construction project, he stops the car and makes us all get out and talks about it. So that kind of sparked my interest” (p. 71-72). Camacho and Lord’s participant described how her father imposed an environment based on his general interest, yet his interest transferred to his daughter, who later decided to study civil engineering. The everyday experiences of students can be sites for interest development that can then translate to skills applicable to engineering ways of thinking (Dorie & Cardella, 2014).

The school environment also plays an important factor in triggering and developing students’ interest. Walkington and Bernacki (2015) found that middle school students’ funds of knowledge (i.e., knowledge and skills that students learn through family, friends, and communities outside of academic institutions), concerning their interest areas, acted as a significant scaffold in conjunction with their prior knowledge of algebraic concepts. Another study examining first-generation college students’ funds of knowledge on interest development found that the behavioral practices of using tools to build things, working with machines and appliances, and fixing things around the house supported interest in engineering (Verdín, Smith, & Lucena, 2020). Often, first-generation college students’ family knowledge and accumulated skills may not be the same as engineers or scientists, but closer to the skill sets of technicians or tradespeople based on their family background (Smith & Lucena, 2016). First-generation college students’ interest may be different than continuing-generation college students based on their unique lived experiences (Smith & Lucena, 2016).

Nevertheless, the knowledge and skills they do gain are still supportive in fostering an interest to pursue an engineering degree. Likewise, engaging in science competitions, tinkering with mechanical devices, and engaging in conversation about science supported first-generation college students’ physics interest (Verdín, Godwin, Sonnert, et al., 2018). Everyday practices and experiences are a result of constructed or selected environments for which these students chose, perhaps due to their positive attitudes towards STEM-related experiences. When students decide to engage in behavioral practices that support an interest in STEM-related topics, they are subsequently selecting an environment that fosters their interest and building positive attitudes towards STEM.

A study by Verdín et al. (2018) found that first-generation college students' experiences that attracted them into engineering were talking about science, tinkering with mechanical and electrical devices, and participation in formal science activities. Continuing to support first-generation college students' interest in engineering is vital. Scholars who study interest caution that "it is incorrect to assume that people with well-developed interest no longer need support" (Renninger & Hidi, 2016, p. 25). Instead, interest develops within one's environment; thus, support and challenges are required to maintain interest, a facet on which educators can capitalize in the classroom (Renninger & Hidi, 2016).

2.11.2 Recognition Understood through the Triadic Model of Reciprocal Causation

Being recognized by others as a physics, mathematics, and engineering type of person as well as internalizing that recognition as a key aspect of identity construction. Receiving recognition as a particular type of person is a response from the environment that validates the behavioral practices and attitudes in which students engage. I situate receiving or being denied recognition through the three forms of environmental factors posed by Bandura, that is, environments that are imposed, selected, and constructed. An imposed environment can both enable and deny recognition as a STEM type of person. For example, the imposed environment of a physics classroom setting was a site where women in a particular sample received recognition as a physics type of person (Hazari, Brewe, Goertzen, & Hodapp, 2017). Specifically, Hazari et al. (2017) found that being recognized as a physics person by high school physics teachers increased the odds of women pursuing a career in physics.

Conversely, in a different study by Verdín et al. (2018), women, first-generation college students, were less likely to have been recognized as a physics type of person by their teachers or peers. Thus, imposed environments can both enable and constrain students' recognition a component important for identity development. In my research, I have come to understand that first-generation college students often do not see themselves as engineers or are recognized by others as engineers when compared to their continuing-generation college peers (Verdín & Godwin, 2017a; Verdín et al., 2020) or when compared to men (Verdín, Godwin, Sonnert, et al., 2018). I believe this lack of recognition is due to environmental structures that have imposed a particular way of being like an engineer. Students can be denied recognition when they are performing their identity under an environment with a narrow view of what is considered a mathematics, physics, or engineering type of person.

Engineering culture is an imposed environment that can shape who students become as culture "is not simply training in a prescribed set of appropriate, academic courses, but is enculturation into a well-established system of practices, meanings, and beliefs" (Tonso, 1996, p. 218). Engineering has historically been highlighted as a male-dominated field, whereas women in the engineering field have been perceived as invaders (Bix, 2004; Slaton, 2015) and this norm of engineering is socially constructed and communicated by the dominant group, namely men, and I would add the women who buy into this cultural norm. Engineering is a community of practice where students aspiring to become members must acquire the cultural norms, values, and behaviors appropriate for this community. Such norms may encompass a student's knowing what it takes to act and be recognized as a competent member of the community (Wenger, 1998). There are behavioral practices that are congruent with the ways of being like an engineer that support or deny recognition. Selecting to participate in this type of environment often forces students to negotiate who they are (i.e., their multiple identities) with who they want to become.

For example Emilia, a participant in Secules, Gupta, Elby, and Tanu's (2018) article, who resisted or refused the imposed engineering culture of masculinity by selecting to keep her femininity in engineering: "I am a girl and I am different from a guy in engineering and that is good. I think I help my team by being different" (p. 16). Emilia resisted changes to her social identity (i.e., being a woman) with the role identity of being an engineer, and whose narrative can be summed up by this statement, "don't ask women to change to be more valued by the engineering system; ask the engineering system to change to (re)value all students in more accurate and gender neutral ways" (Secules et al., 2018, p. 16). In many ways, Emilia was asking (or seeking to construct) an environment that would recognize her as a woman and not through the lens of maleness. However, not all women in engineering will actively resist and push against the culture of engineering, for example, in another study, Bianca, sat in tension with her ethnic identity and the lack of in-group peers in her chemical engineering course, stating, "Sometimes I feel like I don't belong... I'm the only Hispanic girl there, so you turn around and you try to find someone that you feel comfortable ... I don't feel that connection, that bond, so I feel like I'm alone" (Verdín & Godwin, 2018a, p. 277). In the study by Verdín et al. (2018), Bianca felt constrained by the environmental structure in which she found herself. Likewise, in work by Jorgenson (2002), we can see that not all women in engineering enact their agency in the same way as Emilia. Jorgenson (2002) found that women in the engineering profession negotiated the imposed engineering male environment by succumbing to environmental constraints. Sharon, a participant in Jorgenson's (2002) study, asked if the lack of women coworkers in her steel company bothered her, She stated, "No, sometimes I think it was better not to have women to talk to 'cause I know how women get chit chatty … With men, they just come in and work and go home" (p. 366). Sharon had internalized the idea that to be an engineer, she must 'act like the boys' perhaps as a way to receive the external recognition important in identity construction. Nevertheless, Sharon's agency propelled her to select the cultural norms of the imposed environment (i.e., masculine social norms). Being recognized as an engineer requires an individual to "look like an engineer, talk like an engineer, and act like an engineer" (Jorgenson, 2002, p. 355). Similarly, Slaton (2015), who takes a historical look at the engineering profession, affirms that STEM practitioners have often occupied a "particular set of ascribed identities" (p. 175).

Students outside the sphere of the prototypical engineer often receive external messages that conflict with how they see themselves. Diverse students, particularly women, have been sold the idea that an engineer is a certain type of person. For example, two female students, Casey and Penny, "described how the public perception of an engineer is a 'nerdy, white guy with glasses' and who is 'socially awkward'" (Benedict et al., 2018, p. 3). Popular TV shows perpetuate this image of an engineer. Take, for example, the CBS comedy *The Big Bang Theory,* which features the lives of four nerdy, hyper-logical, introverted men in STEM-related professions. While there is no one way of being an engineer, there is a lack of diverse representations and recognition of who can do and who can be in engineering. It is not only popular TV shows that depict a certain way of being like an engineer; engineering for decades has been a "prototypical masculine profession" (Jorgenson, 2002a, p. 351), defined explicitly by a White, Western male perspective I believe the idea that engineers are of a particular type of breed sits in tension with the multiple identities underrepresented students hold. Undoubtedly, those that are not White and male are in continuous negotiations with their multiple identities as they navigate the culture of engineering. Participation in an engineering community of practice not only supports the development of students' identity, but it also means that students are not entirely free to develop any type of engineering identity, rather they are guided by "larger and more pervasive meanings of [engineering] identity derived from sociohistorical legacies of [engineering]; and historical and political meanings of being" an underrepresented student (e.g., Latina, first-generation college student; Carlone & Johnson, 2007, p. 1192).

2.11.3 Performance/Competence Beliefs Understood through the Triadic Model of Reciprocal Causation

The construct of performance/competence beliefs is another component of students' authorship of a disciplinary role identity. When students perform their competence in STEM-related topics or activities, they are enacting the behavioral factor described in the triadic model. The three components of the model continually interact with each other. Therefore, if students are enacting behaviors that demonstrate an affinity towards STEM-related activities, they are subsequently reinforcing their efficacy and fostering a positive attitude (personal factor) towards STEM-disciplines. Additionally, Bandura (1997) stated that "perceived self-efficacy is an important contributor to performance accomplishments, whatever the underlying skills might be" (p. 37). Likewise, Bandura (1986) posited that society is structured in such a way "that patterns of behaviors permitted for some members are prohibited for others" (p. 297). Carlone and Johnson (2007) affirm that science identity is fragile, contingent, situationally emergent, yet students' performance practices and their display of competence triggers recognition as a science type of person from individuals situated in their immediate environment. Therefore, performing one's competence in science or STEM-related domains is a form of bid for recognition by the external environment (Carlone & Johnson, 2007), and internalizing the recognition one receives is contingent on the degree of interest the student holds.

I have presented how interest, recognition, and performance/competence beliefs can be informed through Bandura's model of triadic reciprocal causation. I want to make a point that these three constructs influence each other. Students' ability to understand STEM-related content or feel as if they can do well in the subject areas supports their interest. Likewise, when students demonstrate interest in STEM-related activities or topics, and they perform their competence, their environment subsequently affords them (or denies them) recognition as a STEM-type of person.

2.12 Critical Engineering Agency as a Framework for My Three Studies

Throughout my three studies, I use components of the critical engineering agency framework. In studies 1 and 2, I use the language of hypothesis testing to be consistent with the methodological traditions in the psychological space. In study 3, I seek to answer research questions consistent with qualitative research traditions. In Study 1, I expand the critical engineering agency framework by using the lens of personal agency from a social cognitive theory perspective. Agency is multifaceted; therefore, to capture the different behavioral processes that lead to agentic acts, I focus on creating subconstructs that culminate agentic acts. Creating a scale to capture personal agency expands our understanding of critical engineering agency and how students enact their agency in their daily lives. In Study 2, I use personal agency to understand how first-generation college students enact their critical engineering agency. Specifically, I sought to understand how their engineering identity is shaped through students' personal agency, through the experiences in STEM-related coursework and through students' desires to make a difference in the world. In Study 3, I use the lens of disciplinary role identities, agency, and structures to understand how one Latina through her lived experiences came to see herself as an engineering type of person. This study emphasizes that multiple identities are important as all forms of identities (e.g., role, social, and personal identities) never operate as mutually exclusive. Identities interact with each other depending on the situation and when a particular identity is triggered (Burke & Stets, 2009). It is important to add multiple identities to understand the first-generation college student population as these identities come with unique and varying lived experiences. These experiences are tied to who students are as individuals and how they position themselves and are positioned by others in the world (i.e., their multiple identities).

3. STUDY 1: DEVELOPMENT OF A MEASUREMENT SCALE FOR PERSONAL AGENCY

This chapter highlights a multifaceted understanding of personal agency, capturing the different behavioral processes that lead to agentic acts. Consistent with the theoretical framing of personal agency described in Chapter 2, this study focuses on creating subconstructs for agency beliefs. In this study, I expand on the critical engineering agency framework by using constructs for cognitive behaviors that produce agentic actions.

3.1 The Need for Developing a Measurement Scale for Personal Agency

Missing from the conceptualization of agency, and its application in critical engineering agency is the cognitive processes through which an individual enacts agency. This study aims to identify how cognitive processes of forethought, intention, reactivity, and reflection shape a students' agentic behavior. There is a process through which students' desires for or action towards changing the world or their world is realized. This process is embedded within the four cognitive activities, through the interaction of intentionality, forethought, reactiveness, and reflectiveness, an individual's agentic acts are realized. Moving towards a more precise procedure of the cognitive processes used to enact agency will further expand our understanding of the critical engineering agency framework. Additionally, there have not been ways of quantitatively measuring the cognitive processes of agency for engineering students. Therefore, this paper focuses on describing the development of new items to be used in conjunction with the critical engineering agency framework.

To begin moving towards a cognitive process of enacting agency, I draw on the work of Albert Bandura (1986, 2001, 2006) to better understand the four facets of an individuals' agency. I situate my conceptualization of agency under Bandura's triadic reciprocal causation model theorized under the social cognitive theory (SCT).

3.2 Personal Agency Measurement Instrument Development Process

Using the four cognitive processes of forethought, intentionality, self-reactive, and self-reflective, I developed a measurement instrument to capture engineering students' personal agency. A measurement instrument is an assemblage of items taken together to create a composite score with the intention of revealing a measurable theoretical understanding of the world (DeVellis, 2016). Researchers typically develop scale items to measure abstract concepts, referred to as latent variables. A latent variable or construct is a "representation of something that does not exist as an observable dimension of behavior, and the more abstract the construct, the more difficult it is to measure" (Hinkin, 1998, p. 3). For example, engineering identity is a theoretical concept that cannot be directly observed because of its complexity and abstractness. However, multiple characteristics, features, or indicators of the construct, clusters, or categories can be identified, leading to an understanding of engineering identity. In the absence of an adequate and appropriate measurement instrument, researchers must develop reliable and valid scales (Hinkin, Tracey, & Enz, 1997). The American Psychological Association (APA) outlines procedures that need to be taken into consideration to ensure the appropriate operational definition of the measured construct, which consist of content validity, criterion-related validity, and internal consistency (Association, Association, & on Measurement in Education, 1999; DeVellis, 2016; Hinkin, 1998).

3.3 Purpose of Study 1

The purpose of this study was to create a measurement instrument with strong validity evidence to measure personal agency (or agency for short) using the constructs outlined by Bandura (2001, 2006): forethought, intentionality, self-reactiveness, and self-reflectiveness. Developing an instrument to measure personal agency will support the broader goal of this dissertation. It will expand the critical engineering agency framework by accounting for first-generation college students' personal agency as they cultivate their engineering identity.

The following hypotheses serve to determine the reliability of the personal agency belief scale and the extent to which first-year engineering students can distinguish between the four constructs.

H1. A revised, reliable measure of personal agency beliefs built using Bandura's four constructs of agency (i.e., intentionality, forethought, self-reactiveness, self-reflectiveness) can be achieved with engineering students.

H2. First-year engineering students will conceptually distinguish between the four elements of personal agency.

3.4 Method

The method for revising the scale to measure personal agency was guided by four systematic steps, each of which has subsequent steps 1) item generation, 2) determine the format for measurement, 3) pilot testing the instrument, and 4) administering the instrument (Pett, Lackey, & Sullivan, 2003). A pictorial representation of the five steps is found in Figure 3.1, along with the subsequent steps. Each of the five steps and their respective sub-steps are described in further detail below.

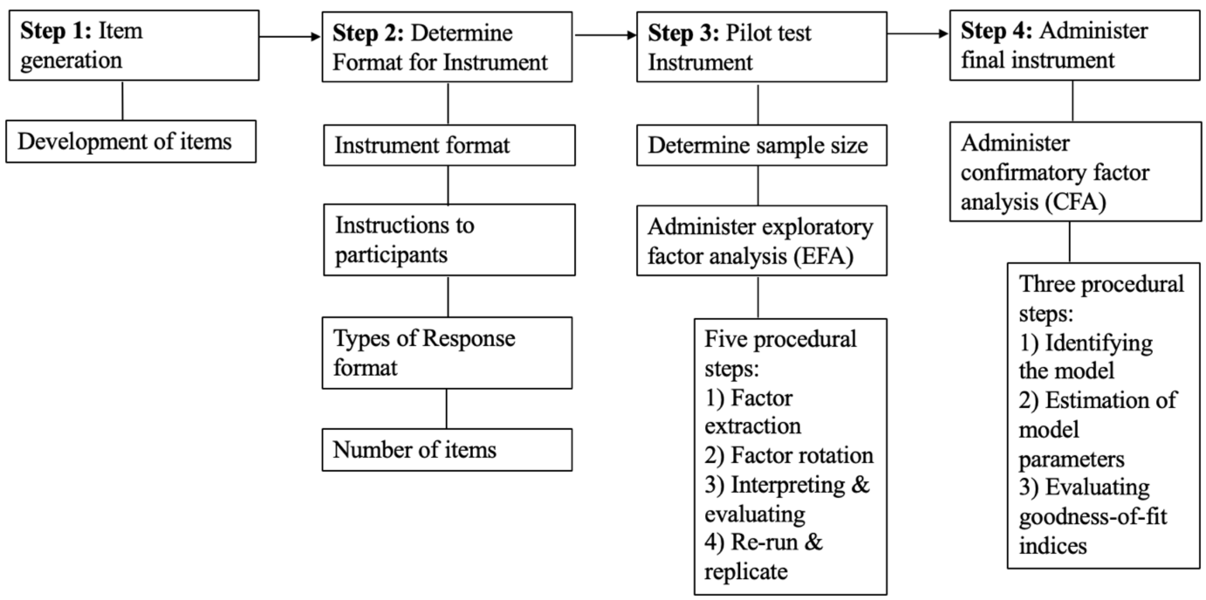

Figure 3.1. Guidelines for Developing a Scale of Personal Agency (Pett et al., 2003)

3.4.1 Step 1: Item Generation

The process of developing a scale for personal agency was based on a deductive approach, where I began with Bandura's (2001, 2006) theoretical definition of personal agency to generate a starting list of items (Hinkin et al., 1997). Bandura's four constructs, forethought, intentionality, self-reactiveness, self-reflectiveness, served as a typology prior to the construction of the personal agency belief items. I conducted a thorough literature search to assess if any personal agency measurement items had been created using Bandura's four constructs. Results from the initial search found only one study that created and tested items based on Bandura's constructs of agency.

The study by Yoon (2011) used the personal agency constructs of intentionality, forethought, self-reactiveness, and self-reflectiveness to examine the relationship between agency, vocational identity, and career decision self-efficacy workforce education and development for undergraduate students broadly. Yoon (2011) also claimed that before his study, no measure using Bandura's personal agency constructs had been developed. His resulting instrument, Assessment of Human Agency[1] (AHA), was tested, and strong validity evidence for the use of the developed measures was found through both exploratory and confirmatory factor analysis (Yoon, 2011).

Yoon's (2011) process for the development of the AHA instrument was guided by the standards set forth by the American Educational Research Association's (AERA) classification of construct validity, criterion validity, and reliability (AERA et al., 1999). Exploratory factor analysis (EFA) helps researchers "develop theory regarding the nature of the [personal agency] constructs" and allows for an early exploration of whether the model is useful in providing a parsimonious description and relationship between the observed variables (Everitt & Hothorn, 2011; Thompson, 2004, p. 5). Confirmatory factor analysis (CFA) tests *a priori* relationship between the observed variables and the degree to which the model fits can be quantified using a different dataset. Therefore, I found it appropriate to use items of the AHA instrument for my study as prior efforts were made to ensure reliability and validity for the instrument.

Upon examining the 12-item AHA instrument, it became clear that modifications were warranted if the items were to be used to elicit student-centered agency. The original study by Yoon (2011) pilot tested 28 items, and through EFA and CFA, he finalized the Assessment of Human Agency (AHA) instrument to 12 items. The modifications, including simplifications of words, adding more context to the survey items, and removing double-barreled questions I made to the AHA instrument, are discussed in the sections that follow and illustrated in Table 3.1. All 28 items appear in the first column of Table 3.1, except for the self-reflectiveness items. The self-reflectiveness items in the AHA instrument were not used for the construction of the personal agency beliefs instrument; instead, a separate instrument consisting of reflectiveness items was used. My rationale for excluding Yoon's (2011) items for reflectiveness are as follows, it was not clear how the items were created, factor loadings for the items were low compared to the other constructs, some items cross-loaded onto other constructs, and in general Yoon tested the items on a diverse population (i.e., graduates and undergraduates) and non-student population (i.e., university administrators).

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[1] Human agency and personal agency are used interchangeably. In Yoon's (2011) study, he uses the phrase human agency. In my study, I will use personal agency as this is phasing is consistent with Bandura's publications on agency.

I chose to use the reflection items from Kember et al. (2000) as this research group was more transparent in grounding their items through Dewey and Mezirow work. Kember's et al.'s (2000) Reflection Questionnaire[2] measured students' habitual action, understanding, reflection, and critical reflection; in this study, I only used the construct for reflection. The Reflection Questionnaire was designed to be a diagnostic tool for promoting reflective thinking and reflection upon practice (Kember et al., 2000). Similar to the AHA instrument, the Reflection Questionnaire psychometric properties were established using EFA/CFA. The reflection questionnaire was "designed for the use of academic programs," and it was specifically tested in undergraduate and graduate health science courses (Kember et al., 2000, p. 393). The wording of the Reflection Questionnaire instrument was not specific to a discipline. The authors affirm there is "no reason why it should not be suitable for other disciplines" (Kember et al., 2000, p. 393).

Modification of Items

As previously stated, upon reviewing the Assessment for Human Agency (AHA) instrument, items warranted modifications. I felt that some of the items from the AHA instrument did not fully capture the four constructs' essence to its fullest. I followed the recommendations offered in the *Handbook for Survey Research* regarding "optimal questionnaire design based on conventional wisdom" (Marsden & Wright, 2010, p. 623). The following list summarizes conventional guidelines on item development and modification (Krosnick & Presser, 2010, p. 624):

1. Use simple, familiar words (avoid technical terms, jargon, and slang).
2. Use simple syntax.
3. Avoid words with ambiguous meanings, i.e., aim for wording that all respondents will interpret in the same way.
4. Strive for wording that is specific and concrete (as opposed to general and abstract).
5. Make response options exhaustive and mutually exclusive.
6. Avoid leading or loaded questions that push respondents toward an answer.

[2] In the U.S., scholars tend to use survey instrument, whereas, outside the U.S., scholars refer to surveys as questionnaires. For my study, I will use the term survey instrument, unless referencing a study conducted outside the U.S.; in such cases, I will use their terminology.

7. Ask about one thing at a time (avoid double-barreled questions).
8. Avoid questions with single or double negations.

Following the eight guidelines above, I sought to optimize students' responses and reduce cognitive load in answering survey items. The cognitive work of responding to survey items is a process that involves interpreting a question and deducing it to a specific intent, searching through one's memories for relevant information, then integrating the information retrieved into a single judgment, and lastly, "translate the judgment into a response, by selecting one of the alternatives offered by the question" (Krosnick & Presser, 2010, p. 625). Minimizing the effort exerted by this cognitive process may ensure optimal response. Lastly, the eight guidelines reduce the task's difficulty and may help maximize respondents' motivation to respond to the entire survey. In some instances, certain words were replaced, while in others, a new survey item was created.

Table 3.1 illustrates how the personal agency constructs from the AHA instrument were modified while other items were completely rewritten or added. For example, the first item originally stated, *I have end results in mind before I begin something*; my modification consisted of switching *end results* with *goals* for simplicity in wording (Guideline 1) and alignment with the theory of personal agency. Similarly, the second item was modified from "accomplish important *things*" to "accomplish important *assignments"* to elicit class and school assignments or projects (Guideline 4). On other occasions, I felt the sentence structure needed modification for clarity and directness, such as, "*I have a specific purpose when I commit to something*" was improved to state, "*I have a specific purpose when I make a commitment*." The item was modified to elicit a declarative statement, as opposed to a passive statement (Guideline 2). A declarative statement is strongly worded without ambiguity, whereas a passive statement may result in high response agreement and insufficient response variability (Pett et al., 2003). Lastly, three new items were created to measure the intentional actions of setting goals. Additionally, I rewrote two items to be negatively worded (reverse items). Scholars recommend adding reverse worded items in questionnaires to alert inattentive responders, correct for response acquiescence, and help reduce bias (Swain, Weathers, & Niedrich, 2008). In general, I centered the survey questions on setting goals and intentional and purposive planning, which is consistent with the construct of intentionality and helps situate the student in the context of higher education. Being purposeful about the environment where personal agency is taking place was important for the development of a student-centered agency survey scale and wording specificity communicates a uniform meaning across respondents (Converse & Presser, 1986). All survey items are closed-ended questions, not suggestive of a particular answer (Guideline 6).

The survey items for the construct reflectiveness were borrowed from the Reflection Questionnaire by Kember et al. (2000). Table 3.2 illustrates how certain items from the Reflection Questionnaire were modified while other items were completely rewritten or added. For example, questions that were double-barreled were simplified or broken up into two questions (Guideline 7). I also adhered to Guidelines 1 and 2, which prompted me to use simple and familiar words, especially for a population of first-year undergraduate students.

Table 3.1. Track changes of the original items from Yoon (2011) and their respective justification.

Original items by Yoon (2011)	Modified and New Questions	Justification
Intentionality		
1. I have end results in mind before I being something.	1. I have goals in mind before I begin something.	1. Agency acts are oriented towards goals, I wanted to be more explicitly targeted towards goals (Guideline 4).
2. I make lists of things that need to be done.	2. Item 2 from Yoon (2011) was not used in my survey.	2. This item was not used in the development of my personal agency scale.
3. I set goals to accomplish important things.	3. I set goals to accomplish important tasks.	3. Given that this scale is for FYE students I wanted to leverage student tasks (Guideline 1).
4. I have specific goals in mind when I complete tasks.	4. I complete tasks without knowing the end goal.	4. This is a reverse coded item, helps to ensure that students are paying attention to the survey question. Serves as an attention checker.
5. I plan daily (e.g., using to do list, calendars, or PDAs).	5. I make intentional decisions on how to accomplish a task.	5. This item is completely new are replaces the 'I plan daily'. I intended to drive home the idea of intentional actions (Guideline 4).
6. I have a specific purpose when I commit to something.	6. I have a specific purpose when I make a commitment.	6. This item is similar to the item by Joon Yoon (2011) with the removal of 'something' to be clearer (Guideline 3).
	7. I set goals that are achievable.	7. This item is new and says the same thing as the above items, I included a 7th item that was simple (Guideline 1) and specific to the construct of making intentional actions (Guideline 4)
	8. I make commitments without having a purpose in mind.	8. I created an additional reverse coded item to alert inattentive survey responders.

Table 3.1 continued

Forethought 1. I imagine possible future events in my life. 2. I consider the possible consequences of each plan when choosing a plan of action. 3. I forecast my future in terms of the next several years. 4. I consider various courses of action likely to produce desired outcomes. 5. I imagine various opportunities that might be open to me in five years. 6. I consider the potential negative consequences of my prospective actions. 7. I consider the potential positive consequences of my prospective actions.	1. I imagine possible future events in my life. 2. I consider possible consequences when making plans. 3. I imagine my future in terms of the next five years. 4. I consider many courses of action to reach my goals. 5. I can imagine opportunities that might be open to me in the next five years. 6. I weigh the pros and cons before executing an action. 7. Item 7 from Yoon (2011) was not used in my survey. 8. I don't think over a situation before I acting on it.	1. This item was directly taken from Yoon's (2011) study. 2. This item is modified to achieve simplicity (Guideline 1). 3. I changed the word forecast with imagine to minimize confusion, as this word is more often to describe 'weather forecast' and my goal is to elicit easy and quick reactions to the survey items (Guidelines 2, 3, and 4). 4. The outcome of an agentic act was to actualize a goal (big or small). Stating goal in the survey items is intentionally specific to prompt personal agency beliefs (Guideline 4). 5. Added the word 'can' for clarity and to declare an active action (Guideline 3). 6. This item replaces item six from Joon Yoon's forethought survey items, follows the suggestions of Guidelines 1 and 4. 7. Recreated into a reverse coded item. 8. I created an additional reverse coded item to alert inattentive survey responders to alert the survey responder as suggested by Swain et al.(2008)

Table 3.1 continued

Self-Reactiveness		
1. I actively keep myself on track to complete my plans.	1. I actively keep myself on track to complete my plans.	1. This item was directly taken from Yoon's (2011) study.
2. I monitor my plans and actions so my goals will be met.	2. I monitor my plans and actions so my goals will be met.	2. This item was directly taken from Yoon's (2011) study.
3. I adjust my plans when I realize something is going wrong.	3. I adjust my plans when necessary.	3. This item was simplified by removing the text, 'when I realize something is going wrong' to simply state 'when necessary.' Also, the goal of this item is not to elicit reactiveness *only* when things go wrong but as a general form of adjustment to the environment.
4. I try to find more effective ways to fulfill my objectives.	4. I keep myself motivated to reach my goals.	4. This item was rewritten to use common phrases (Guideline 1).
5. I move my plans into action without procrastination.	5. My plans become actions.	5. I simplified this survey item (Guideline 1), removed unnecessary jargon, i.e., without procrastination, (Guideline 2), and avoided potential double-barreled question (Guideline 7).
6. I keep myself motivated to reach my goals.	6. I keep myself motivated to reach my goals.	6. This item was directly from Yoon's (2011) study.
7. I complete the tasks I have planned for the day.	7. Item 7 from Yoon (2011) was not used in my survey.	7. This item was not used in my scale to avoid confusions by students who may complete tasks at a longer length of time than previously planned.
	8. I monitor my plans to achieve my goals.	8. A new simplified version of question 2 was created that explicitly elicit achieving a goal. Achievement of a goal is a common phrase and adds to the underlying theoretical definition of the self-reactiveness.

Note: In the second column, words were colored in red to demonstrate where I made changes. The third column provides justification for the changes that were made.

Table 3.2. Track changes of the original items from Kember et al. (2000) and their respective justification.

Original items from Kember et al.'s (2000)	Modified and New Questions	Justification
1. I sometimes question the way other do something and try to think of a better way. 2. I like to think over what I have been doing and consider alternative ways of doing it. 3. I often reflect on my actions to see whether I could have improved on what I did. 4. I often re-appraise my experiences, so I can learn from it and improve for my next performance.	1. I reflect on the way others do something to think of a better way of doing it. 2. I think over what I have done to consider alternative ways of doing it. 3. I reflect on my actions to see if I could have made improvements. 4. I think about my experiences, so I can learn from them. 5. I think about my experiences to improve on my next performance. 6. I think about my past performance to guide my future actions.	1. The original item was a double-barreled question. I made the question flow as one with clear reference to the act of reflecting (Guidelines 4 and 7) 2. Made this question flow as one concrete action rather bordering between a double-barreled question (Guidelines 4 and 7). 3. I made this item simple and clear by removing 'to see whether I could have improved on what I did' to simply state 'have made improvements' (Guideline 1 and 2). 4. The original item by Kember et al. was a double-barreled question. I divided the question into two separate items, as seen in items 4 and 5 (Guideline 7) 5. Survey question 6 is a new item that that elicits reflection upon action. Scholars suggest that when developing a survey scale to pilot test minimum of 6 items (Hinkin et al, 1997).

Note: In the second column, words were colored in red to demonstrate where I made changes. The third column provides justification for the changes that were made.

3.4.2 Step 2: Determine Format for Instrument

Pett and colleagues (2003) outlined six steps for arranging items in a "meaningful format that will allow the data to be collected effectively and efficiently" (p. 31). The six components are 1) instrument format, 2) printed layout, 3) instructions to the participants, 4) wording and structure of the items, 5) response format, and 6) the number of items, which are described in the subsections that follow.

Instrument Format

The personal agency beliefs instrument used a seven-point anchored numeric scale. An anchored scale is a summative rating scale method that measures beliefs, personalities, and attitudes (Likert, 1932; Pett et al., 2003). A study by Matell and Jocoby (1971) compared the use of various scales from a 2-point through 19-point format to determine the "optimal number of alternatives to use in the construction of a Likert-type scale" (p. 659). Their study found evidence, from multiple tests, that "reliability and validity are independent of the number of scale points used for Likert-type items" (p. 666). There seems to be no universally agreed-upon standard for the number of points on a rating scale. Some studies have affirmed that rating scales beyond 7-points does not increase reliability and can create additional cognitive load (Krosnick & Presser, 2010). Therefore, I stopped exactly at 7-points since the odd number provides clarity to the meaning of the scale points and gives participants a *Neutral* reference point, which adds reliability (O'Muircheartaigh, Krosnick, & Helic, 2000). The options in-between the neutral reference point and strongly agree, for example, adds the option of respondents who are moderately in agreement with the statement or who are moderately neutral to the statement. Numbers with equal intervals were placed above each of the bubbles to show equal distance from one point to the other, creating equal intervals. Krosnick and Presser (2010) note that providing verbal labels to the endpoints adds clarity as "responders task may be made more difficult when presented with numerical rather than verbal labels" (p. 271). Another study offered guidelines for choosing scales documented that a 7-point scale with the endpoints labeled is appropriate for surveying student population and for conducting analyses estimating linear relationships (i.e., correlations, regression models, structural equation models, etc. (Weijters, Cabooter, & Schillewaert, 2010)). Lastly, a 7-point scale is consistent with the other scale items in the survey administered in the Fall of 2017 to first-year engineering students and allows for easy interpretation of results. The 7-point rating scale was fill in the bubble format, as depicted in Figure 3.2.

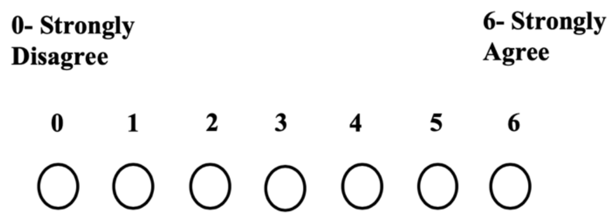


Figure 3.2. Seven-Point Likert Scale Format

Printed Layout

All questions for the personal agency measurement scale were blocked together, students responded to the personal agency items one after another, appearing as a battery of items. The items were not grouped into their respective constructs; rather, they were randomized. Randomizing the order of survey items mitigates sematic ordering effect, which can affect motivation and produce fatigue (i.e., by reading several similar questions, one after the other) (Krosnick & Presser, 2010).

Instructions to the Participants

Participants were prompted to respond to the following question in the personal agency beliefs scale: “To what extent do you agree or disagree with the following statements.” This form of instruction is consistent with the use of the Likert-type anchor numeric scale technique, were statements are offered to respondents, and respondents are asked to indicate their level of agreement (Krosnick & Presser, 2010). This prompt was chosen to assess students’ level of agreement with the developed scale items and to maintain consistency throughout the survey as this prompt style appears for other questions.

Response Format

In my study, I used two response formats, paper-and-pencil and online format. The paper-and-pencil format was administered in a Scantron booklet where students were allowed to fill in the corresponding answer in pencil. A paper-and-pencil format is optimal because it receives higher response rates than computer-based surveys (Shih & Fan, 2009). Research on the use of online versus paper-based surveys demonstrated higher response rates for surveys administered "face-to-face" (Nulty, 2008). Additionally, administering the survey via paper-pencil format mitigates whether students will have access to computers during class. However, at times, passing out a physical copy of the survey and collecting it from students can waste class time. Therefore, I also used an online survey format when the time allocated to administer the survey was limited. I discuss the use of these two formats in the section titled Data Sources.

Number of Items

Tabachnick and Fidell (2013) suggest when conducting factor analysis, a minimum of three variables (survey items) should be used to explain one latent construct (e.g., intentionality). While Hinkin and colleagues (1997) recommend that scales should comprise of four to six items for each latent construct, with the anticipation that "approximately one-half of the items will be retained for use in the final scales" (p. 4). Given these suggestions, the initial personal agency belief scale is comprised of six to seven items per latent construct.

3.4.3 Step 3: Pilot Test the Instrument

The pilot study was conducted in the Spring of 2017 with a group of second-semester, first-year engineering students. Sampling first-year engineering students was purposeful, given that these students are the target population for the final personal agency belief instrument. The codebook with survey items used in the pilot instrument can be found in Appendix A. By testing the instrument with first-year engineering students, my study captures the incoming attitudes and beliefs of this population before they have been enculturated into a particular way of thinking like an engineer. The target population for Study 2 (Chapter 4) are first-year engineering students; thus, best practices for scale development advise researchers to validate the survey scale using the target population.

Determine Sample Size

Tabachnick & Fidell (2013) suggest that "sample sizes in the range of 100-200 are acceptable with well-determined factors (i.e., most factors defined by many indicators, i.e., marker variables with loadings > .80) and communalities (squared multiple correlations among variables) in the range of .50" (p. 618). Another researcher suggests that a minimum of 100 participants should be sampled to conduct an effective exploratory factor analysis (Gorsuch, 1997). There is general disagreement about the adequacy of sample size, some scholars citing a minimum of 100 (Fabrigar & Wegener, 2011; Gorsuch, 1997), Kline (2014) cited a sample size above 1,000 would be desirable, whereas Cattell (1978) cited, "good stability is reached by about 250 subjects," then added, "certainly 500 subjects would be a good number to aim" (p. 509). MacCallum, Widaman, Preacher, and Hong, (2001) surveyed the literature and found several 'rules of thumb' for sample size suggestions included minimum sample of 100 or 500 observations, as well as guidelines in terms of a ratio $N{:}p$ (i.e., N is the sample size and p number of variables being analyzed). Through a simulation study, MacCallum et al. (2001) concluded that rules of thumb and recommended ratio are not useful alone, but dependent on other aspects of the design study. Specifically noting that when communalities are above .5, it is "not difficult to achieve good recovery of population factors, but one must have well-determined factors (not a large number of factors with only a few indicators each) and possibly a somewhat larger sample, in the range of 100 to 200" (MacCallum et al., 2001, p. 96).

Performing Exploratory Factor Analysis (EFA)

An exploratory factor analysis (EFA) was conducted using the pilot dataset. EFA "operates on the notion that measurable and observable variables can be reduced to fewer latent variables" (Yong & Pearce, 2013, p. 80). This method helps researchers "develop theory regarding the nature of the [personal agency] constructs" and allows for early exploration of whether the model is useful in providing a parsimonious description and relationship between the observed variables (Everitt & Hothorn, 2011; Thompson, 2004, p. 5). EFA allows for an exploration of the relationship between the observed variables and latent variables; no prior restrictions on the model are set. Lastly, in scale development and construct validation, conducting an EFA is often a precursor to confirmatory factor analysis (CFA; Brown, 2015). All statistical procedures were conducted using the R programming statistical language (R Core Team, 2018). The following five procedural aspects of EFA, as outlined by Brown (2015, p. 37), were used to analyze the dataset, i) factor extraction, ii) factor selection, iii) factor rotation, iv) interpreting factors and evaluating the quality of the solution, and v) re-run and replicate the factor analysis.

Before conducting the five recommended procedures, I tested the data for possible violations of univariate and multivariate normality. Univariate normality implies that the data fall within a bell-shaped sampled distribution and multivariate normality implies that the sampled distribution of means and the linear combinations are within a bell-shaped sampled distribution (Tabachnick & Fidell, 2013). A violation of univariate normality would result in the skewness of an absolute 2.0 or higher and kurtosis of an absolute 7.0 or higher (Fabrigar, Wegener, Maccallum, & Strahan, 1999). Mardia's Test was used to examine multivariate normality; this test examines "skewness and kurtosis coefficients as well as their corresponding statistical significance" (Korkmaz, Goksuluk, & Zararsiz, 2014, p. 4). The correlation matrix was analyzed to determine if any items were non-significant. When items failed to meet normality standards or were not significantly correlated with other items designed to measure the same latent factor, they were removed from the analysis. Lastly, I tested for multivariate outliers using Mahalanobis distance. Mahalanobis distance calculates how far an observed variable is from the center of the distribution, "which can be thought of as the centroid in multivariate space" (Korkmaz et al., 2014, p. 158).

i. Factor Extraction. The minimum residual method is an appropriate factor extraction method, especially when data violates the assumptions of multivariate normality. An ML estimation is used when assumptions of multivariate normality are not violated (e.g., skew > 2; kurtosis > 7; Fabrigar et al., 1999).

ii. Factor Selection. I used a parallel analysis to determine the appropriate number of factors. Another popular method for determining the number of factors is a Scree plot; however, a parallel analysis provides a more objective criterion for the number of factors (Brown, 2015; Fabrigar & Wegener, 2014). The parallel analysis approach consists of using the eigenvalues from the obtained data and comparing these values to a random sample generated by the statistical software (Brown, 2015; Fabrigar et al., 1999). The results of this test indicate how many latent factors exist.

iii. Factor Rotation. Two types of rotations can be used: orthogonal and oblique. Oblique rotation was used in this analysis. Oblique rotations allow for correlation among common factors and "provides a more accurate and realistic representation of how constructs are likely to be related" (Fabrigar et al., 1999, p. 282). Additionally, if an oblique rotation is selected and the factors are uncorrelated, the oblique rotation will produce results similar to an orthogonal rotation. Interrelated factors will only be accurately produced using an oblique rotation (Brown, 2015; Fabrigar & Wegener, 2014).

iv. Interpreting factors and evaluating the quality of the solution. In this step, several considerations are warranted, such as determining if the factors are meaningful and interpretable, eliminating poorly defined factors, and items behaving poorly (Brown, 2015). A poorly defined factor consists of factors that only have one or two items loaded onto it and/or factors items with low loadings. Item communality should fall between 0.40 to 0.70 (Costello & Osbourne, 2005). Tabachnick and Fidell (2013) noted that variables with loadings < 0.32 should be removed from the analysis. Additionally, items that are cross-loaded will be removed from further analysis. Worthington and Whittaker (2006) state that cross-loading exists when "factors share items that cross-load too highly on more than one factor (e.g., > .32)" (p. 821).

v. Re-run and replicate the factor analysis. This step highlights how EFA is an iterative process; that is, once an item has been dropped due to low factor loading or high cross-loading, the analysis is re-run. Each time the model is re-specified, the resulting factor analysis can change; therefore, each modification must be done one at a time. The model is re-evaluated for the factors and quality described above. The final EFA solution should be replicable using a separate dataset; this sets the groundwork to run future data with predetermined measurement models in a CFA (Brown, 2015).

3.4.4 Step 4: Administer Instrument

In the Fall of 2017, the Dr. Allison Godwin's CAREER: Study of Students' Underlying Attitudes and Beliefs in Engineering (NSF 1554057) survey was deployed to first-year engineering students at 32 ABET-accredited U.S. institutions. The personal agency items that were administered in the CAREER survey are outlined in Appendix A. In the sections that follow, I describe considerations taken for conducting the confirmatory factor analysis on the data.

Performing Confirmatory Factor Analysis (CFA)

Both EFA and confirmatory factor analysis (CFA) seek to reproduce the observed relationship between a group of indicators; yet, they are fundamentally different (Brown, 2015). Whereas EFA uncovers the complex pattern structure by exploring the dataset and testing predictions, CFA follows an *a priori*, researcher-specified relationship between the observed variables and the degree to which the model fit can be quantified using a different dataset. Additionally, CFA is "employed to evaluate the reliability of a testing instrument in a manner that overcomes limitations of traditional methods (e.g., Cronbach's alpha)" (Brown, 2015, p. 320). In a CFA, the researcher, in advance, indicates the number of factors, the pattern of indicator-factor loadings, and specifies errors (e.g., random or correlated error indicators; Brown, 2015). In EFA, the researcher does not place any constraints on the variables loading onto the factors, whereas, in CFA, the researcher is allowed to create relationships between particular factors while others are constrained to zero loadings (Gentleman, Hornik, & Parmigiani, 2008).

Maximum likelihood CFA follows the same assumptions of multivariate normality as maximum likelihood EFA; therefore, data will be tested for violation of univariate normality (i.e., skewness of an absolute 2.0 or greater and kurtosis of an absolute 7.0 or greater; Fabrigar et al., 1999). The CFA was conducted using the lavaan package (Rosseel, 2012) in the R programming statistical language (R Core Team, 2018). The following three procedural steps were followed when conducting a CFA a) identifying the model, b) estimation of model parameters, and c) evaluating goodness-of-fit indices.

a. Identifying the model. The method of identifying the model is guided by the results found in the exploratory factor analysis. Irrespective of the number of factors, the latent variables will need to be scaled by either fixing the error of latent variable to 1 (Brown, 2015). This step also involves ensuring that an under-identified model is not created. A model is under-identified when the amount of information in the input matrix (e.g., indicators variances and covariances) are the same as or exceed the amount of freely estimated model parameters ("e.g., factor loadings, factor variances/covariances, indicator error variances/covariances"; Brown, 2015, p. 71).

b. Estimation of model parameters. This process entails producing a predicted variance-covariance matrix that resembles, as closely as possible, the sampled variance-covariance matrix (Brown, 2015). The fitting function that will be used is the maximum likelihood (ML). The use of ML estimation in a CFA is to "find the model parameter estimates that maximize the probability of observing the available data if the data were collected from the same population again" (Brown, 2015, p. 73). This procedure is iterative and conducted through a statistical software.

c. Evaluating goodness-of-fit indices. Fit indices can be categorized as follows: a) absolute fit, b) fit adjusting for model parsimony, and c) comparative fit. Absolute fit determines model fit at an absolute level, which is considered "perfect" fit. The absolute fit examines at chi-square statistic and standardized root mean square residual (SRMR). Chi-square evaluates the difference in overall fit and discrepancy between the sampled and fitted covariance matrices. Chi-square should yield a non-significant p-value ($p > .05$), although this test is known to be sensitive to large sample sizes (Brown, 2015; Kline, 2015). Where the SRMR is "viewed as the average discrepancy between the *correlations* observed in the input matrix and the correlations predicted by the model" (Brown, 2015, p.82). SRMR falls between 0.0 to 1.0, where 0.0 would indicate a perfect fit. Root mean square error of approximation (RMSEA) is a widely recommended index to test for parsimony; it's an "error of approximation" index because it determines how well the model fits within the population (Brown, 2015; Steiger & Lind, 1980). A close fit would indicate the RMSEA is less than or equal to 0.05 and less than or equal to 0.08 for moderate fit (Brown, 2015; Maccallum, Browne, & Sugawara, 1996). Comparative fit index (CFI) "evaluates the fit of a user-specified solution in relation to a more restricted, nested baseline model" and has a range of 0.0 to 1.0, where 1.0 implies good model fit (Brown, 2015, p. 84). Lastly, the Tucker Lewis Index (TLI), another comparative fit index, should have acceptable values close to 1.0 (Brown, 2015).

In addition to examining the goodness-of-fit indices, items and latent constructs were evaluated by examining standardized factor loadings, determining the degree of internal consistency, and convergent validity. Guidelines suggested by Hair, Black, Babin, and Anderson (2010) state that "individual standardized factor loadings should be at least 0.5 and preferably 0.7" (p.632). However, since the factor loadings impact model fit, internal consistency, and convergent validity, I decided to retain only items that were above 0.60 to be conservative. Internal consistency will be evaluated using Cronbach's alpha. Cronbach's alpha evaluates the extent to which the items, specified in a construct, measure the same construct; values should be above 0.70 (Cronbach, 1951; Tavakol & Dennick, 2011). Convergent validity will be evaluated by looking at the average variance extracted (AVE). AVE measures the amount of variance captured by the latent construct against the amount that is attributed to measurement error. An AVE value below 0.50 indicates that the measurement error is larger than the variance captured by the constructs and its respective items; therefore, values should be above 0.50 (Fornell & Larcker, 1981).

3.5 Data Sources

After describing the four systematic steps by Pett et al., (2003), and their subsequent steps, for developing the scale to measure personal agency I will present the data sources used in my analysis. Two separate datasets were used to validate the scale for personal agency: 1) pilot dataset and 2) a large-scale dataset. The pilot dataset was used to run the initial exploratory factor analysis. The large-scale dataset was used to run a secondary exploratory factor analysis and a confirmatory factor analysis.

3.5.1 Pilot Dataset

A pilot study was conducted in Spring 2016 with a group of second-semester, first-year engineering students at a large Midwestern university. The rationale for pilot testing to first-year engineering students was because the intention of the survey is to capture incoming engineering students' attitudes and beliefs before they have been enculturated into a certain way of thinking. The survey was administered online using Qualtrics software. The use of the Qualtrics software for the pilot survey was intentional in that it allowed for quick and easy administration. The engineering course where the pilot survey was administered could only allocate five minutes given the tight schedule; thus, an online survey allowed for time-efficient processing. The purpose of this pilot data was to begin the process of validating the revised personal agency scale before administering the large-scale survey. Fifteen items were tested. The pilot dataset does not contain demographic information due to classroom time constraint; therefore, none are presented in this study. The pilot sample size was n = 113, scholars Tabachnick and Fidell (2013), Gorsuch (1997), and Kline (2014) suggest that a minimum of 100 participants should be sampled to conduct an effective EFA. However, I also acknowledge that there are inconsistencies between scholars regarding the adequate sample size for exploratory factor analysis. For example, scholars have suggested 300 participants (Yong & Pearce, 2013), while another study noted that low communalities would require a larger sample size (MacCallum et al., 2001). Therefore, I used the pilot dataset to validating items that were modified and created. I also used a subsection of the large-scale dataset to conduct another exploratory factor analysis as a way to add more evidence of validity.

To verify hypothesis 1 (i.e., H1. A revised, reliable measure of personal agency beliefs can be built using Bandura's four constructs of agency [i.e., intentionality, forethought, self-reactiveness, self-reflectiveness] can be achieved with engineering students) and hypothesis 2 (i.e., H2. First-year engineering students will conceptually distinguish between the four elements of personal agency, i.e., forethought, intentionality, self-reactiveness, self-reflectiveness), two datasets were used. I describe the need to conduct two EFA analysis a section below.

3.5.2 Large-Scale Dataset

Data for this analysis were collected in the fall of 2017 semester as part of a grant titled CAREER: Actualizing Latent Diversity: Building Innovation through Engineering Students' Identity Development. Schools sampled were stratified by the number of engineering students enrolled by small (7,750 or less), medium (7,751 to 23,050), and large (23,051 or above) based on data from the Integrated Postsecondary Database System (U.S. Department of Education, & Institute of Education Sciences National Center for Education Statistics, n.d.). One-third of the sample was randomly recruited from each stratified list to ensure that the sample had representation from the numerous small schools in the U.S. and avoid overrepresentation in responses from large, public engineering institutions. The large-scale survey was administered via paper-and-pencil format, specifically as a Scantron booklet, with the capability to be semi-automatically digitized into a comma-separated values file. The Scantron booklet was created by the Scantron Company and contain individual identification numbers.

The survey was administered at thirty-two institutions offering degrees accredited by the Engineering Accreditation Commission of ABET to students in introductory engineering courses. After cleaning the dataset, the overall sample of first-year engineering students was 3,711. A full information maximum likelihood method was used to account for missing values in the dataset using the Amelia II package (Honaker, King, & Blackwell, 2011). This method was appropriate as Honaker and colleagues (2011) state that multiple imputations "reduce bias and increases efficiency compared to listwise deletion" (p. 3).

3.5.3 Overall Student Demographics from the Large-Scale Dataset

Of the total sample of first-year engineering students that took this survey, the gender breakdown is as follows 720 (19%) female-identified students, 2150 (58%) male-identified students, 14 (0.04%) genderqueer, 17 (0.06%) agender, 70 (2%) transgender, 75(2%) a gender not listed, and 782 (21%) students did not indicate any gender from the list provided to them in the survey. Often students do not complete the survey due to fatigue, lack of time or loss of interest, I believe this was the case for the 782 (21%) students.

The race/ethnicity breakdown is 380 (10%) Asian, 209 (6%) African American/Black, 347 (9%) Latino/a or Hispanic, 65 (2%) Middle Eastern or Native African, 34 (1%) Native Hawaiian or other Pacific Islander, 49 (1%) Native American or Alaska Native, 2089 (56%) White, 72 (2%) another race/ethnicity not listed, and 793 (21%) did not indicate any race/ethnicity listed. Students were allowed to select any gender and race/ethnicity for which they identified. For example, out of the 2,089 (56%) students who identified as White, 291 (14%) of them also identified with another race/ethnicity. Additionally, students were asked to report their home zip code; these zip codes were plotted on the U.S. map to provide a geographic distribution of the overall first-year engineering student sample in the dataset—Figure 3.3.

From the sample of 3,711 first-year engineering students, **804 (22%) of students identified as first-generation college students** (i.e., both parents having less than a bachelor's degree) and 2,057 (55%) identified as having one or more parent(s) with a bachelor's degree or higher, and 850 (23%) did not indicate parental level of education or did not fill out the last portion of the survey that asked about their demographics. In the following section, I describe the gender and race/ethnicity of the first-generation college student sample in this dataset.

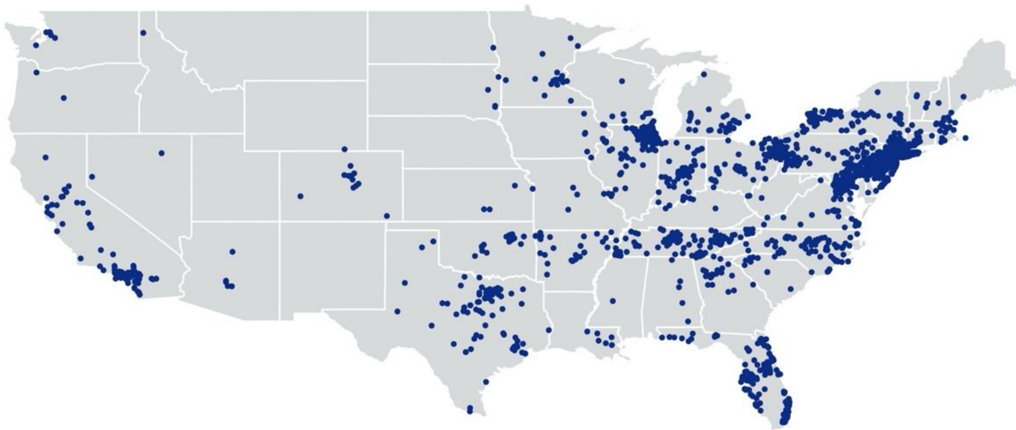


Figure 3.3. Home Zip Codes of all first-year engineering students who participated in the CAREER survey using ggplots2 (Wickham, 2009)

3.5.4 First-Generation College Students Sampled from the Large-Scale Dataset

My sample of first-generation college students consisted of 187 (24%) female identified students, 567 (72%) male identified students, 3 (0.4%) agender, 5 (0.6%) genderqueer, 2 (0.3%) transgender, and 36 (5%) students did not report their gender or identify as female or male. The race/ethnicity breakdown was 93 (13%) Asian, 67 (8%) African American/black, 155 (20%) Latino/a or Hispanic, 20 (3%) Middle Eastern or Native African, 5 (0.6%) Native Hawaiian or other Pacific Islander, 11 (1.4%) Native American or Alaska Native, 408 (52%) White, 19 (2%) another race/ethnicity not listed, and 12 (2%) did not report. Students were asked to report their home zip code; these zip codes were plotted on the U.S. map to provide a geographic distribution of the first-generation college student sample—Figure 3.4.

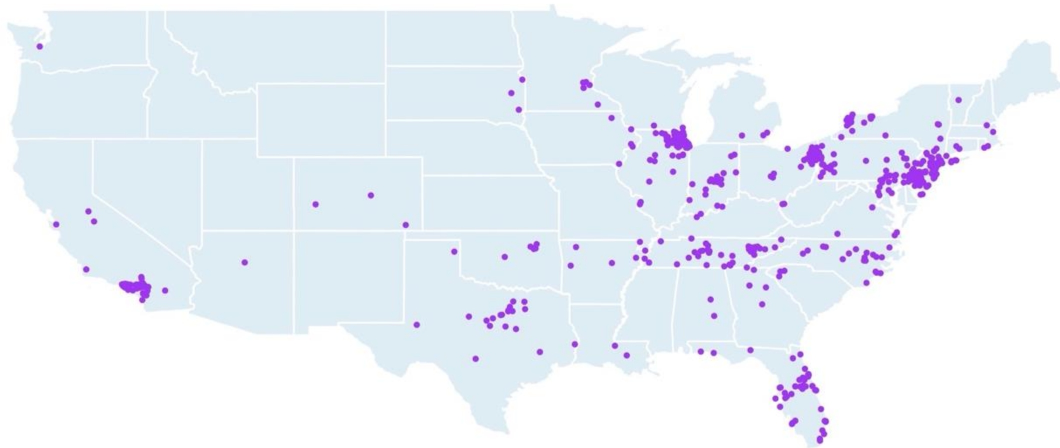


Figure 3.4. Home Zip Codes of *only* first-generation college students in engineering who participated in the CAREER survey using ggplots2 (Wickham, 2009)

3.6 Data-Analytic Strategy

3.6.1 Before Conducting Factor Analysis

First, I examined if the sample size for the pilot dataset was suitable to run an exploratory factor analysis using the Kaiser-Meyer Olkin Measure (KMO) measure of sampling adequacy (Kaiser, 1970). KMO examines the proportion of variance among variables that may be considered to have a common variance. Acceptable values of KMO are 0.50 to 0.70, which are considered mediocre, 0.70 to 0.80 considered good, 0.080 to 0.90 are considered great, and values greater than 0.90 are considered superb (Hutcheson & Sofroniou, 1999).

After examining sample adequacy, the correlation matrix was examined to determine if a patterned relationship exists among the variables. Two methods were used to examine the correlation matrix, visual screening and statistical tests. First, variables were visually examined to determine cases with low correlations ($r < \pm 0.30$) or extremely high ($r < \pm 0.90$). Cases that are too low or extremely high were removed from the analysis due to a lack of pattern relationships and/or multicollinearity problems. Three items were removed, Q1y = I imagine my future in terms of the next five several years., Q1v = I imagine possible future events in my life, and Q1f = I imagine opportunities that might be open to me in the next five years. Second, I ran Bartlett's test to determine if the correlation matrix was significantly different from an identity matrix a significant level of $p < 0.05$ or lower is desired.

Data were screened for univariate and multivariate normality. Univariate normality is achieved if skewness levels are within the absolute value of 2.0 or lower and kurtosis levels are within the absolute value of 7.0 or lower (Fabrigar et al., 1999). Multivariate normality was examined using Mardia's Test (Korkmaz et al., 2014).

3.6.2 Exploratory Factor Analysis

An exploratory factor analysis (EFA) was conducted using the Spring 2017 pilot dataset and a subset of the Fall 2017 CAREER dataset (n = 790). R programming language and statistical software system version 3.5.3 (R Core Team, 2018) was used to conduct all analyses. The exploratory factor analysis was performed through a function under the psych package (Revelle, 2017); see Appendix B for the code. The five procedural aspects of EFA, were used to analyze the two datasets, i) factor extraction, ii) factor selection, iii) factor rotation, iv) interpreting factors and evaluating the quality of the solution, and v) re-running and replicating the factor analysis.

3.7 Results

3.7.1 Exploratory Factor Analysis with Pilot Data Collected in Spring 2017.

Twenty-six items were created for the four latent constructs (i.e., forethought, intentionality, self-reflectiveness, and self-reactiveness). These items were pilot tested in the Spring of 2017 with a second-semester first-year engineering class at a large Midwestern university, $n_1 = 113$. Bartlett's test of sphericity was examined to test the overall significance of all correlations within the correlation matrix; results yield significance at (χ^2 (325) = 1641.74, $p < 0.001$). KMO measure was tested for sample adequacy, KMO = 0.870, indicating an acceptable sample size (Cerny & Kaiser, 1977; Kaiser, 1970). Both Bartlett's test and KMO measure suggest the dataset was appropriate for factor analysis.

All variables were found to be within acceptable limits of univariate normality; skewness was within the absolute value level of less than 2.0 and kurtosis was within the absolute value level of less than 7.0. Mardia's Test was used to test for multivariate normality (Korkmaz, Goksuluk, & Zararsiz, 2014); the test yielded estimates of multivariate skewness $\gamma_{1,p} = 266.399$, $p < .001$ and estimates of multivariate kurtosis $\gamma_{2,p} = 804.650$, $p < .001$. Multivariate normality was not found in the dataset; therefore, an exploratory factor analysis using ordinary least squares (OLS) to find the minimum residual solution was used. Whereas maximum likelihood assumes a multivariate normal distribution, OLS "is not based on any assumptions about the distribution of the measured variables in the population" (Briggs & MacCallum, 2003, p. 28).

First, the correlation matrix was examined, the following variables were deleted due to a lack of correlation with the other variables, Q1f = "I imagine opportunities that might be open to me in the next five years," Q1h = "I complete tasks without knowing the end goal," Q1r = "I make commitments without having a purpose in mind", Q1w = "I don't think over a situation before acting on it," and Q1y = "I imagine my future in terms of the next five several years." The correlation matrix can be found in Appendix C, Table 3.3. Next, factor selection was determined; the number of common factors was determined using scree plots. The scree plot in Figure 3.4 represents the eigenvalues in descending order. The number of eigenvalues that precedes the last major drop is the number of factors specified by the model. Based on the literature, I hypothesized four common factors for personal agency (i.e., forethought, intentionality, self-reactiveness, and self-reflectiveness); however, the scree plot suggests that the number of common factors was two, as opposed to the hypothesized four factors. Similarly, the parallel analysis also suggested the number of factors was two.

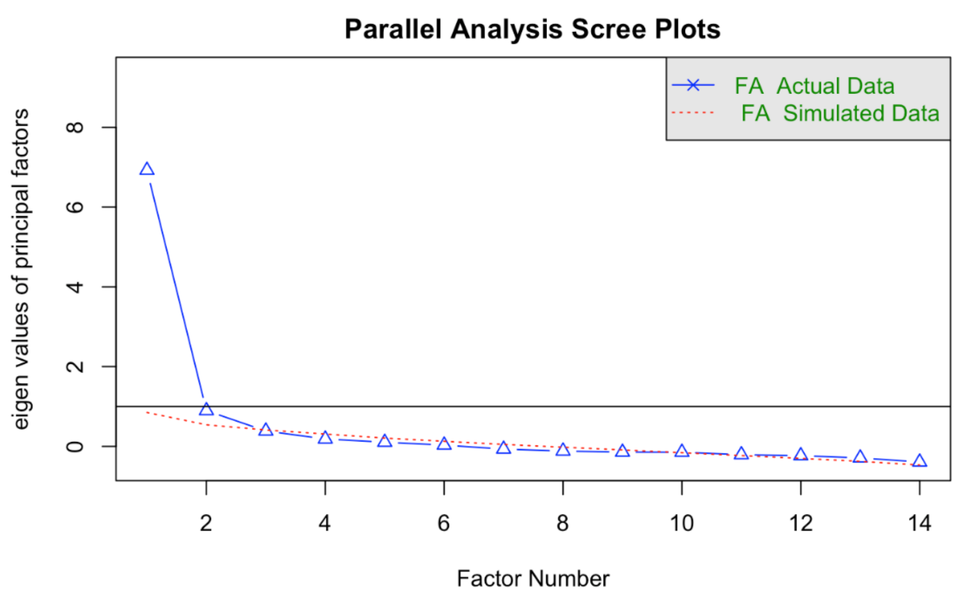


Figure 3.5. Scree Plot Using the Pilot Dataset Collected Spring 2017

The factor rotation method used was an oblique rotation; this type of rotation allows for correlation among common factors. Through an iterative process, items were removed due to the following reasons: low communalities (between 0.40 to 0.70), cross-loaded items (loadings of > 0.32 in each factor), or Heywood cases (communalities exceed 1). The elimination of items was done in an iterative process, with each iteration rerunning the scree plot and the parallel analysis to determine the number of factors. The final two-factor solution can be found in Table 3.4. Factor loadings ranged from 0.44 to 0.85, exceeding the minimum requirement of 0.32. All cross-loading were below the recommended 0.32. Communalities were between 0.40 and 0.70. A total of nine items were removed. The remaining items were then added to the large-scale survey, which was administered at a national level in the Fall of 2017 to first-year engineering students.

Table 3.3. Exploratory Factor Analysis using Pilot Dataset collected Spring 2017

Hypothesized Constructs	Survey Items	Factor 1	Factor 2	Communalities	Uniqueness
Inten.	Q1a = I have goals in mind before I start something.	**0.54**		0.48	0.52
Fore.	Q1b = I monitor my actions to achieve my goals.	**0.76**		0.69	0.31
Reac.	Q1g = I keep myself motivated to reach my goals.	**0.66**		0.47	0.53
Fore.	Q1m = I weigh the pros and cons before executing an action.	**0.65**		0.49	0.51
Inten.	Q1p = I set goals to accomplish assignments.	**0.69**		0.46	0.54
Reac.	Q1q = I actively keep myself on track to complete my plans.	**0.95**		0.65	0.35
Fore.	Q1l = I monitor my plans to achieve my goals.	**0.80**		0.70	0.30
Ref.	Q1c = I think about my experiences so I can learn from them.		**0.68**	0.66	0.34
Inten.	Q1j = I make intentional decisions about how to accomplish tasks.		**0.56**	0.55	0.43

Table 3.3 continued

Ref.	Q1k = I reflect on the way others do something to think of a better way of doing it.		**0.80**	0.55	0.45
Ref.	Q1s = I reflect on my actions to see if I could have made improvements.		**0.81**	0.61	0.39
Fore.	Q1t = I consider consequences when making plans.		**0.52**	0.55	0.45
Ref.	Q1u = I think about my experiences to improve on my next performance.		**0.56**	0.51	0.49
Ref.	Q1x = I think over what I have done to consider alternative ways of doing it.		**0.93**	0.65	0.35
Rotation Sum of Squared Loadings					
Percentage of Variance		0.28	0.26		
Cumulative Percentage		0.28	0.55		

The results of the exploratory factor analysis, conducted using the Spring 2017 pilot dataset, demonstrated an inconsistent factor grouping. For example, items capturing intentionality and self-reactiveness grouped into one factor, that is, students in this dataset were not distinguishing between both constructs. Likewise, items pertaining to forethought factored with items pertaining to self-reflectiveness, intentionality, and self-reactiveness. The goal of the exploratory factor analysis was to determine if the items loaded onto their respective factors, to eliminate items that were not loading well, and to reduce the number of questions in the scale. Although all loadings and communalities are within the acceptable range, for replication, a second exploratory factor analysis was run with a subset of the student population from the large-scale dataset collected in Fall 2017. The subset of students used in the second EFA was not included in the confirmatory factor analysis as this would be an inappropriate approach to factor analysis because the students' parental level of education cannot be determined due to incomplete reporting.

3.7.2 The Need for a Second Exploratory Factor Analysis

As MacCallum et al. (2001) stated, if communalities are above .50, sample sizes between 100 and 200 are adequate. I can conclude that the sample size used in the first EFA (n_1 = 113) was insufficient since a sufficient number of communalities were below .50. Therefore, I decided to run a second exploratory factor analysis to achieve indisputable validity evidence. All personal agency survey items that demonstrated strong item reliability were added to the large-scale survey. There were two purposes for running another factor analysis, first obtaining a clear understanding of how the constructs are functioning and second due to disagreement among the community regarding adequate sample size. The factor analysis using the pilot data showed that the items for forethought were loaded onto both factors as opposed to one factor. It is difficult to determine if this phenomenon is a result of having sampled *one* first-year engineering class, the correlation among variables, the lack of distinguishability among the items or a combination of several issues.

3.7.3 Second Exploratory Factor Analysis with a Subset of the Large-Scale Dataset Using Students who did not Report Parental Level of Education.

I had a second opportunity to re-run a second exploratory factor analysis using a subset of the large-scale dataset. The large-scale dataset had already been parsed out between first-generation college students, continuing-generation college students, and students who did not report their parents' level of education for unknown reasons. I used the sample of students who did not report their parental level of education, n = 850, to re-run the exploratory factor analysis. It is difficult to determine why students do not report their parents' level of education; some possible reasons may include survey fatigue, inadequate time allocated to administering the survey in class, or the student did not know parents' level of education.

First, thirty-four outliers were removed from the sample using Mahalanobis distance, leaving a sample size of n = 816. Levels of univariate skewness and kurtosis were examined and found to be within acceptable ranges (i.e., skew > 2; kurtosis > 7). Mardia's test for multivariate normality failed to reject the null hypothesis of multivariate normality, skewness values $\gamma_{1,p}$ = 12.292, p < .001 and kurtosis values $\gamma_{2,p}$ = 236.712, p < .001, indicating the dataset is non-multivariate normal. However, Bartlett's test was significant at (χ^2 (66) = 5700.17, p < 0.001) and KMO = 0.930, both test indicating that the sample dataset is adequate for factor analysis. The correlation matrix was examined; all variables demonstrated significant correlation— see Table

3.5 in Appendix D. Similar to the pilot dataset, I used ordinary least squares minimum residual as my factor extraction method. The factor selection method used as a Scree plot and parallel analysis. The Scree plot was examined to determine number of common factors. The previous factor analysis found two common factors; however, using a subset of the large-scale dataset, a three common factors structure was also suggested—see Figure 3.5. Parallel analysis also suggested a three common factor structure. However, upon examining the factor loadings, in the three common factor structure, there was significant cross loadings (loadings of > 0.32 in each factor) in several items. Thus, I decided to revert to the two-factor structure as was found within the pilot dataset.

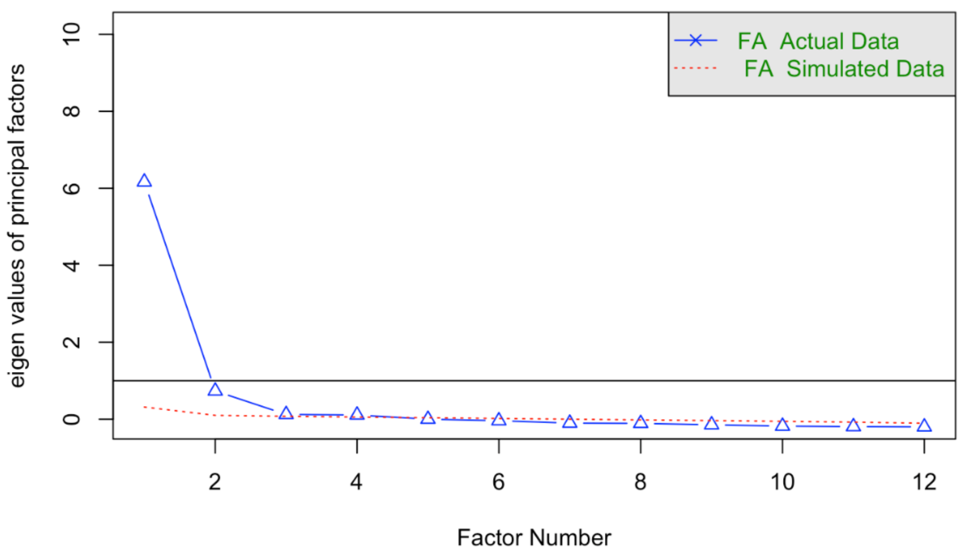


Figure 3.6. Final Scree Plot Using a Subset of the Large-Scale Dataset Collected in Fall 2017

The factor rotation used was an oblique rotation due to the correlational nature of the variables. Results of the two-factor structure can be found in Table 3.6, upon evaluating the quality of solution all items had acceptable factor loadings, communalities, and no significant cross-loading. Running this second exploratory factor analysis helped clarify the construct groupings. That is, all items measuring forethought grouped with items measuring self-reflectiveness. Although theory posits that forethought and self-reflectiveness are two distinct psychological constructs, students in this dataset are interpreting the constructs similarly. Measure of construct consistency was calculated using Cronbach's alpha, reflectiveness/forethought α = 0.885 and intentionality/reactiveness α = 0.905, both indicating acceptable construct validity.

Table 3.4. Exploratory Factor Analysis using data from student who did not report parental level of education in the Large-Scale Dataset Collected in Fall 2017 (*n* = 850)

Hypothesized Constructs	Survey Items	Factor 1	Factor 2	Communalities	Uniqueness
Ref.	Q8o = I think over what I have done to consider alternative ways of doing it.	**0.83**		0.69	0.31
Ref.	Q8n = I think about my experiences to improve on my next performance.	**0.82**		0.71	0.29
Fore.	Q8i = I weigh the pros and cons before executing an action.	**0.73**		0.57	0.43
Fore.	Q8m = I anticipate potential consequences when making plans.	**0.71**		0.54	0.46
Refl.	Q8l = I reflect on my actions to see if I could have made improvements.	**0.69**		0.60	0.40
Fore.	Q8d = I consider many courses of action before making plans.	**0.58**		0.51	0.49
Reac.	Q8f = I keep myself motivated to reach my goals.		**0.72**	0.60	0.40
Int.	Q8e = I set goals to accomplish assignments.		**0.78**	0.65	0.35
Int.	Q8g = My plans become actions.		**0.75**	0.66	0.42
Reac.	Q8j = I actively keep myself on track to complete my plans.		**0.71**	0.61	0.39
Reac.	Q8b = I monitor my actions to achieve my goals.		**0.78**	0.64	0.36
Rotation Sum of Squared Loadings					
Percentage of Variance		0.28	0.25		
Cumulative Percentage		0.28	0.54		
Proportion Explained		0.53	0.47		

3.7.4 Confirmatory Factor Analysis

Using my target population, first-generation college students, I conducted a confirmatory factor analysis to validate the findings from the previous model, outlined in Table 3.6 above. The first-generation college student sample size in the large-scale dataset is n = 804.

Levels of skewness and kurtosis were examined with this new dataset, all variables were within the acceptable range (i.e., skew > 2; kurtosis > 7). Multivariate normality was examined using Mardia's test. Similar to exploratory factor analysis, multivariate normality was not found in this dataset skewness values $\gamma_{1,p}$ = 19.127, $p < .001$ and kurtosis values $\gamma_{2,p}$ = 251.576, $p < .001$. For this analysis I used a Satorra-Bentler adjusted chi-square test for goodness of fit, due to a lack of multivariate normality. Results from the Satorra-Bentler chi-square goodness of fit yield X^2_{SB} = 130.784 df = 43, $p < .001$. The fit indexes were CFI of 0.967, TLI of 0.958, RMSEA of 0.051 CI (0.044 – 0.058), and SRMR of 0.039. The CFI and TLI values were above 0.90, reflecting good model fit (Hu & Bentler, 1999). The RMSEA value was below the recommended 0.080 value indicating good model fit with an upper confidence interval limit value also below 0.080 (Brown, 2015).

Table 3.7 provides the unstandardized and standardized factor loadings, standard error, item reliability, construct reliability, and average variance extracted for the personal agency constructs. Standardized factor loadings were above the recommended 0.45 minimum cutoff value. Item reliability for each indicator was above the recommended 0.50 minimum cutoff value. Construct reliability was examined using Cronbach alpha, intentionality/reactiveness α = 0.857 and reflectiveness/forethought α = 0.899 both of which are above the recommended 0.70 minimum cutoff value for each latent construct. Lastly, the average amount of variance extracted (AVE) by each latent construct was above the recommended 0.50 cutoff value, intentionality/reactiveness AVE value 0.664 and forethought/self-reflectiveness AVE value 0.641. Figure 3.6 demonstrates the first-order factor structure for the personal agency constructs of intentionality/reactiveness and self-reflectiveness/forethought. A second-order factor structure was examined to determine if the two constructs, intentionality/reactiveness and forethought/self-reflectiveness, produce a second-order latent variable called personal agency. The second-order structure can be found in Figure 3.7 and Table 3.6 provides their unstandardized and standardized factor loadings, standard error, and item reliability. The factor structures' fit indices (i.e., CFI, TLI, RMSEA, SRMR) along with the information criterion indices (i.e., BIC and AIC) are identical to each other. Typically, BIC and

AIC are used to compare CFA models that vary, balancing good-fit with parsimony (Kline, 2016). However, all of these indices appear identical because I had to constrain one parameter to be 1 (i.e., the second-order variable of personal agency). Given that both factor structures have the same fit indices and freely estimated parameters, I chose to use the second-order structure because I can obtain the measure for the proportion of the variance that's explained for each factor (i.e., R-square).

Through exploratory and confirmatory factor analysis, I found two groupings, as opposed to four: intentionality with self-reactiveness and forethought with self-reflectiveness. The two-factor structure demonstrated acceptable values of item and construct reliability. Based on this grouping, I conclude that engineering students in my study conceptualized setting intentional plans (intentionality) and construction of appropriate courses of action to achieve these plans (self-reactiveness) similarly. The two factors (i.e., Factor 1 = intentionality/self-reactiveness and Factor 2 = forethought/self-reflectiveness) was evident in the factor loadings for the two exploratory factor analysis conducted in this study. The grouping of the latent constructs was then validated using confirmatory factor analysis; all survey items demonstrated acceptable values of item and construct reliability. It is not uncommon that a scale developed using a particular sample population will function differently for another, as was the case in my study.

Table 3.5 Confirmatory Factor Analysis for the First-Generation College Student Population in the Large-Scale Dataset Collected Fall 2017 (*n* = 804)

Latent Variables	Indicators	Un/Std. Factor Loading	*SE*	Item Reliability	Construct Reliability	AVE
First Order Latent Constructs						
Intentionality/Reactiveness					0.87	0.62
	Q8f = I keep myself motivated to reach my goals.	0.50***/0.80	0.03	0.64		
	Q8e = I set goals to accomplish assignments.	0.45***/0.80	0.03	0.64		
	Q8g = My plans become actions.	0.45***/0.78	0.03	0.61		
	Q8j = I actively keep myself on track to complete my plans.	0.50***/0.80	0.03	0.64		
	Q8b = I monitor my plans to achieve my goals.	0.43***/0.76	0.03	0.58		
Forethought/Reflectiveness					0.89	0.58
	Q8o = I think over what I have done to consider alternative ways of doing it.	0.50***/0.77	0.03	0.59		
	Q8n = I think about my experiences to improve on my next performance.	0.54***/0.82	0.04	0.68		
	Q8i = I weigh the pros and cons before executing an action.	0.54***/0.70	0.04	0.50		
	Q8m = I anticipate potential consequences when making plans.	0.57***/0.77	0.04	0.59		
	Q8l = I reflect on my actions to see if I could have made improvements.	0.54***/0.80	0.04	0.64		
	Q8d = I consider many courses of action to reach my plans.	0.48***/0.71	0.03	0.50		
Second-Order Latent Constructs						
Personal Agency						
	Intentionality/Reactiveness	2.03***/0.90	0.15			
	Reflectiveness/Forethought	1.50***/0.83	0.13			

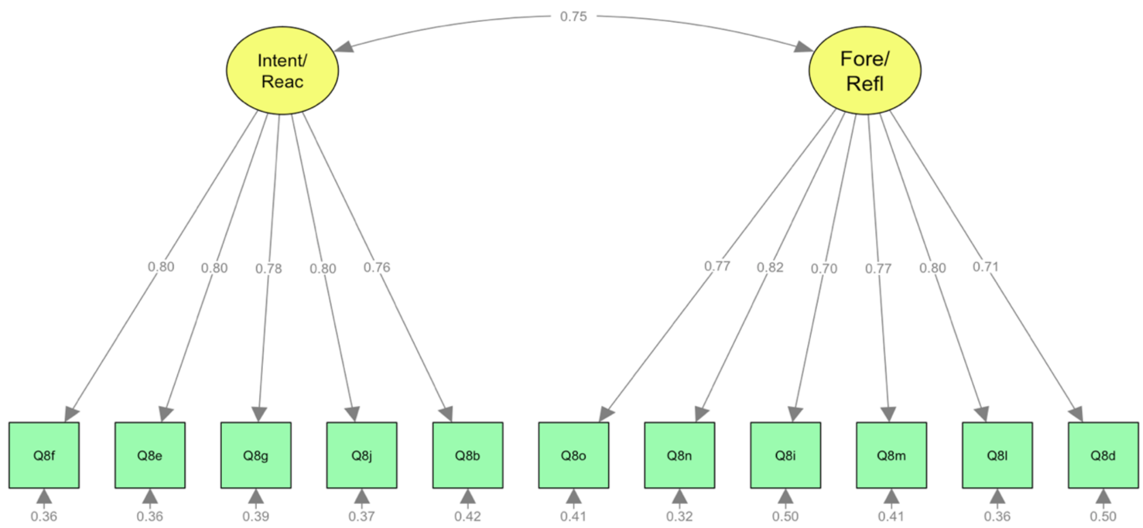


Figure 3.7. Results of first-order confirmatory factor analysis for personal agency

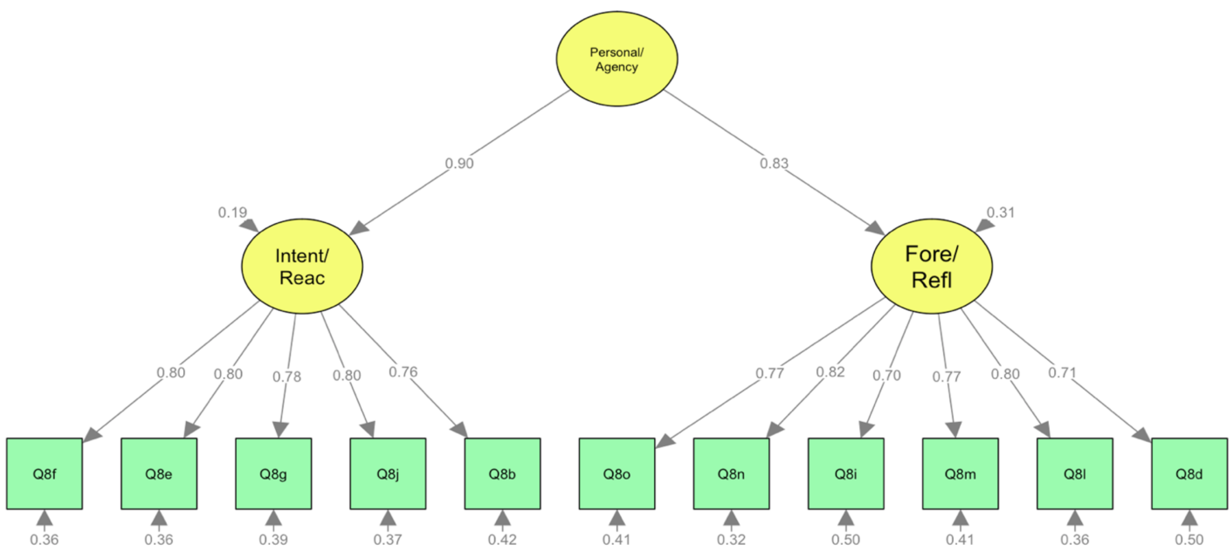


Figure 3.8. Results of second-order confirmatory factor analysis for personal agency

3.8 Discussion of Hypothesis 1

Study 1 introduced social cognitive theory through a personal agency perspective; I created a scale to capture first-generation college students' personal agency. My first hypothesis was that a reliable measure for personal agency could be created. Based on my extensive literature review of personal agency, the work of Yoon (2011) was the first to create and validate a scale for personal agency using the four cognitive processes of forethought, intentionality, self-reactiveness, and self-reflectiveness as outlined by Bandura (2001; 2006). However, modifications to the existing personal agency scale by Yoon (2011) were necessary. I used survey items from Yoon's (2011) original scale, making minor changes to several items. I did not use Yoon's (2011) question for the self-reflectiveness construct; rather, I adopted a completely different scale—see Appendix A. I made changes to Yoon's (2011) items based on the theory of personal agency from Bandura (2001; 2006) and being cognizant of Krosnick and Presser's (2010) conventional guidelines for developing survey scales. The goal of research question one was to validate a revised version of Yoon's (2011) scale and determine the construct validity among each factor. To do so, I needed to understand how first-generation college students in engineering conceptualized the constructs of forethought, intentionality, self-reactiveness, self- reflectiveness. Through exploratory and confirmatory factor analysis, I found two groupings, as opposed to four, that is intentionality with self-reactiveness and forethought with self-reflectiveness. The two-factor structure demonstrated acceptable values of item and construct reliability. Henceforth, one factor will be labeled intentionality/reactiveness and the other factor will be labeled forethought/reflectiveness.

3.9 Discussion of Hypothesis 2

After revising the AHA scale, my second hypothesis was that engineering students could conceptually distinguish between the four elements of personal agency beliefs (i.e., forethought, intentionality, self-reactiveness, self-reflectiveness). The modification, addition, adoption of items required scale validation through exploratory and confirmatory factor analysis. Through exploratory and confirmatory factor analysis, I found that engineering students in my study conceptualized setting intentional plans (intentionality) and construction of appropriate courses of action to achieve these plans (self-reactiveness) in a similar manner. Likewise, the engineering students in my study conceptualized future-directed planning (forethought) and the ability to analyze prior experiences and thought processes (self-reflectiveness) similarly. These two groupings (i.e., intentionality with self-reactiveness and forethought with self-reflectiveness) were evident in the factor loadings for the two exploratory factor analysis conducted in this study. The grouping of the latent constructs was then tested using confirmatory factor analysis; all survey questions demonstrated acceptable values of item and construct reliability. It is not uncommon that a scale developed using a particular sample population will function differently for another. Yoon's (2011) initial survey validation sampled a broad population, i.e., undergraduate students, graduate students, administrators, nontraditional students, and students enrolled in online degree programs. Additionally, Yoon's (2011) recommendations for future research specifically encouraged scholars to "study a specific population" (p. 105).

3.10 Expanding Critical Engineering Agency by Understanding Students' Agency

The critical engineering agency framework describes students' learning processes as (1) understanding engineering, (2) identifying oneself as someone with engineering habits of mind, (3) constructing and using engineering, and broadly STEM, in personally and socially meaningful ways, (4) imagining and constructing a socially just and equitable world, and (5) engaging in action that is personally and socially transformative (Basu et al., 2009; Godwin, 2014; Godwin & Potvin, 2017; Godwin et al., 2016; Turner, 2012). Missing from the framework was a clear understanding of how students' agentic capabilities to influence events that affect their lives and the world around them were realized. Agency is a capability that every individual holds, that is, it is present in all human actions. Grounded from a psychological perspective, personal agency is based on internal thought processes that operate in a multidirectional cyclical process. Forward-directed planning is done and anticipated outcomes are foreseen (forethought), the achievement of an anticipated outcome or goal involves intentional actions (intentionality), appropriate courses of action are undertaken (self-reactiveness), and where reflection upon action is taken (self-reflectiveness; Bandura 1989, 1999, 2001, 2006). However, students are not situated in a vacuum; rather, they are positioned within larger social structures and these social structures also push back against agentic acts. Students' personal factors, behavioral factors, and environment play a role in enacting their agency. Therefore, I ground my conceptualization of personal agency and critical engineering agency through Bandura's (1986) triadic reciprocal causation model. The triadic reciprocal causation model is consistent with Turner's (2003) framing of critical mathematics agency, which positions students' in social, cultural, political and historical systems within the education and society at large (i.e., the environmental factors that are imposed, selected, and constructed).

Identity and agency are intimately tied, that is, the capacity students hold to make changes in their lives, and the world around them subsequently fosters identity development. There is variability among the research community regarding how agency is operationalized. Critical engineering agency draws on the work of Holland et al., which defines agency as "the realized capacity of people to act upon their world ... purposively and reflectively, to reiterate and remake the world in which they live..." (Holland et al., 1998, p. 42) and now draws on the work of Bandura (1989) to frame personal agency as "people's beliefs about their capabilities to exercise control over events that affect their lives" (Bandura, 1989, p. 1175).

3.11 Study 1 Supports Study 2

In order to identify the strengths that first-generation college students enter engineering with, this study supports study 2, which seeks to model how this population of students develop their engineering identity. The capacity students hold to exercise control over events that effect their lives and the world around them subsequently fosters identity development. I hypothesize that first-generation college students' personal agency influences their engineering role identity because identity development is not a passive endeavor; rather, identity is created, recreated, and sustained through participation in activities and reflexivity (Brickhouse & Potter, 2001; Roth et al., 2004). Studies 2 and 3 will capture this dynamic interplay using both quantitative and qualitative data of first-generation college students.

4. STUDY 2 ENACTING AGENCY: HOW FIRST-GENERATION COLLEGE STUDENTS' AGENCY SUPPORTS THEIR DISCIPLINARY IDENTITY DEVELOPMENT AND ASPIRATIONS OF MAKING A DIFFERENCE

In the previous study, I outlined a process for developing a measurement scale for personal agency and tested the scale for validity evidence using exploratory and confirmatory factor analysis. The agency items I created are intimately connected to the critical engineering agency framework I will use throughout the remainder of the two studies. This study will utilize the newly developed personal agency scale using structural equation modeling analysis to understand how measures of agency and disciplinary role identity support first-generation college students' engineering identity.

4.1 Introduction

In my published work, I have come to witness how first-generation college students are dedicated to their pathways into and through higher education and aspire to serve their communities through their post-secondary educational attainment. For example, Elizabeth[3], a committed electrical engineering major and a first-generation college student stated,

> I never said, "I'm not going to finish it or I'm going to do business instead of EE [electrical engineering]." ... No, that was never an option for me ... I think those who do change their major I think they're weak or not committed ... commit, just do it, nothing comes easy, nobody gives you anything for free, you need to work for it. (Verdín & Godwin, 2018a, p. 276)

Another first-generation college student, Bianca, held altruistic aspirations for studying engineering, rooted in supporting students from her community. She said, "I wanted to do something that had to do with education, helping the students, bringing more Hispanics into science ... if I do engineering I can ... be a role model for other students..." (Verdín, Godwin, & Morazes, 2015, p. 11). Bianca's aspirations to be a role model to other underrepresented students like herself came from her personal experience,

[3] All names are student-chosen pseudonyms.

> Nobody told me I had the potential to do science ... but I believe that I have potential and I believe that a lot of Latino students in high school ... they [teachers and/or administrators] see them more like they are going to drop out of high school, they are not going to graduate and they see them as a lost cause, and in them, there are so much potential. (Verdín & Godwin, 2018a, p. 276)

Sam, a first-generation, first-year engineering student, grew up moving from place to place, "depending on how rent was in the area ... It was very difficult to have a place to live. Sometimes rent was short." Nevertheless, she "kept good math scores" and was considered an elite math student. She said, "I was in a small class ... we were taking Algebra I as seventh graders, which she emphasized was not the norm in her school district; they called us the elite." Sam, in her senior year in high school, was taking a multivariable calculus course in college (Verdín & Godwin, 2019, p. 2). Lastly, Lupe, a first-generation college student in her sixth year as a mechanical engineering student, held aspirations towards making a difference with her degree. "One thing I do want to do with my degree is be able to give back to a community," she shared. Specifically, Lupe desired to give back to her mother,

> I wanna make money to help my mom, to get her out of what we are in now ... I would see that she would sometimes have to work two jobs just to help pay the rent at the time and she owned a house ... Unfortunately, we lost the house so now we're renting. (Verdín & Godwin, 2019, p. 2)

Together these stories illustrate how first-generation college students are shaped and reshaped by their environment; they are agentic individuals, informed by the past, oriented towards the future, and are capable of adapting to current circumstances (Emirbayer & Mische, 1998). These prior studies describe a counternarrative of first-generation college students, a narrative that emphasizes the capabilities they bring to engineering.

While environmental factors shape individuals, individuals *can*, in turn, shape their environment (Burke et al., 2003; Burke & Stets, 2009; Stryker & Burke, 2007); this recursive process influences the self in various stages of a student's life course. An individual shapes society or their world around them by exercising their personal agency. Personal agency is the capability a person holds to make choices and to act on those choices in ways that make a difference in their lives (Bandura, 1999a). I illustrate this point through Sam's narrative. Sam, when asked how she came to be where she is today, stated,

> Coming from a low-income family, both of my parents did not have a college education. My mom had very little middle school education. So, I knew that a powerful tool for me would be graduating high school and pursuing a degree in college…

Sam’s narrative is not an uncommon narrative for students who are the first in their families to attend college. Sam’s reflection of her parents’ reality as individuals with minimal formal education, is also a reflection of her environment and constitutes the enactment of personal agency. That is, a student is “as much an agent when reflecting on [their] experience[s] as when executing a particular course of action” (Martin, 2004, p. 138). Bandura maintained that through an agentic perspective, individuals could imagine futures that propel action in the present moment, “modify alternative courses of action to secure valued outcomes, and override environmental influences” (Bandura, 2008a, p. 87).

I explicitly situate Sam, Lupe, Bianca, Elizabeth, and first-generation college students broadly, through an agentic perspective. Foregrounding agency as the lens through which to understand first-generation college students is a way of acknowledging that these students are active contributors to their life course by selecting, influencing, and constructing their environment. Drawing from the narrative of Sam, Lupe, Bianca, and Elizabeth, I outline how enacting one’s agency influences first-generation college students’ belief of seeing themselves as engineers and using engineering as a tool to make a difference in their world. The capacity individuals hold to make changes in their lives, and their world around them subsequently fosters identity development; thus, agency and identity are intimately tied (Holland et al., 1998). Where agentic behaviors include intentional actions, planning is done, anticipated outcomes are foreseen, appropriate courses of action are taken, and reflection upon action is taken. The agency first-generation college students enact towards seeing themselves as the type of people that can be an engineer and subsequently fulfill one’s intention of making an impact in their community through engineering is the premise of this study.

4.2 Seeing Oneself as the Type of Person that can do Engineering

First-generation college students’ disciplinary role identities are closely associated with agency and learning, “learning is ... a process of coming to be, of forging identities in activity ...

[learners] are becoming certain sorts of subjects with certain ways of participating in the world" (Brickhouse et al., 2000, p. 443). Disciplinary role identities are formed by the product and byproduct of activities where students gain interest, performance/competence beliefs, and recognition by others (Cribbs et al., 2015; Godwin et al., 2016; Hazari et al., 2010). These identities are not an "a priori constituent of activity but [are] something that are made and remade as activities unfold and when individuals participate in multiple activity systems" (Roth & Barton, 2004, p. 16). First-generation college students' disciplinary identities are as much an outcome of their actions (i.e., personal agency) as it is of the environmental factors. Therefore, I ground my work on first-generation college students' lived experiences in a triadic model of reciprocal causation (Bandura, 1986) where students' personal factors (e.g., cognitive abilities, self-efficacy beliefs, and attitudes), behavioral factors (e.g., performance and skills), and environmental factors (e.g., social-cultural settings) play a role in developing their disciplinary identities and enacting their agency.

Students who enroll in engineering programs in some way see themselves as individuals who can do engineering and become engineers. This continuously developing engineering identity is cultivated through learning experiences before and during college. High school learning experiences, both in-and-out of the classroom, have benefited students' decision to pursue an engineering major in college (Cass et al., 2011; Dabney et al., 2012; Godwin, Sonnert, & Sadler, 2015, 2016; Ozis, Pektaş, Akça, & DeVoss, 2018; Paulsen, Cardella, Jones, & Wolsky, 2015; Phelps, Camburn, & Min, 2018; Potvin et al., 2009; Walcerz, 2007). In a study using data from the National Education Longitudinal Study tracking students from eighth grade through their mid-twenties (i.e., while in college), Maltese and Tai (2011) found that over half of students majoring in STEM reported having chosen their major during high school. Another study examining trends of students' intention to pursue engineering career at four fluctuating time points, middle school to the beginning of college, found that 37% of students, from their dataset, became interested in engineering at the beginning of high school while 81% became interested by the end of high school (Cass et al., 2011). A qualitative study of high school students enrolled in physics and chemistry courses found that students' with a high interest in pursuing an engineering career associated being a ""mathematically and scientifically minded" person as someone who can do engineering" (Verdín, Godwin, & Ross, 2018, p. 39). A recent study by Cruz and Kellam (2018) found that a common narrative among undergraduate engineering students who were 'called to adventure' (i.e., "call to adventure for engineering students is represented by whatever might have sparked students' initial interest in the engineering profession" (p. 562)) were attributed to tinkering experiences as a child, engagement AP courses, and had skill and interest in mathematics and science. Interest is a powerful motivator towards pursuing an engineering degree and has been shown to foster external and internal recognition of seeing oneself as an engineer (Godwin et al. 2016). Taken together, experiences, both in-and-out of the classroom, inform students' interest in the STEM-relate activities they choose to engage in, allow them to evaluate their know-how skillset in the various tasks, and shape students' perceptions of themselves as individuals who can participate in STEM.

4.3 First-Generation College Students Pre-College STEM-Related Experiences

Seeing oneself as an engineer *is "both a product and a byproduct of activity"* (Tonso, 2006, p. 274, italics added). Having experiences in STEM-related areas allows for external recognition by school personnel, family members, or meaningful others and recognition is important for disciplinary identity development (Carlone & Johnson, 2007; Gee, 2001; Godwin, Potvin, et al., 2016; Hazari, Sonnert, Sadler, & Shanahan, 2010; Varelas, 2012). Interest, recognition, and general engagement with engineering activities occur during students' pre-adolescent and adolescent years. These learning experiences can shape their perceptions of seeing themselves as individuals that can do engineering.

When I started researching the influence pre-college experiences on the intention to pursue engineering for students who are the first in their families to attend college (i.e., first-generation college students), the literature available was sparse. One reason may be due to the designation of first-generation college students starts to be tracked at the beginning of college when students are filing their financial aid forms and/or college applications. Nevertheless, a number of scholars sought to examine the experiences that have supported first-generation college students', mostly using free-reduced lunch as a proxy for socioeconomic status or school type, intention to pursue engineering, which helps shed light on the pre-college engineering experiences for this particular group of students.

My survey of the literature will discuss early childhood experiences to college-readiness for students who are or will be the first in their families to attend college. Early experiences, provided through an individual's environment, are critical for the development of STEM interest, from a child's early years (Ainley & Ainley, 2015; Harlan, 1996; Low et al., 2005), to their secondary education (George & Kaplan, 1998; Gilmartin, Li, & Aschbacher, 2006; Godwin & Potvin, 2017; Godwin, Sonnert, & Sadler, 2015; Maltese, Melki, & Wiebke, 2014; Maltese & Tai, 2011; Verdín, Godwin, Sonnert, et al., 2018). In a study examining the income gaps in early childhood experiences, parents in the bottom tenth income percentile were less likely to hold a bachelor's degree or higher and less likely to report that their child used computers for activities such as learning reading and/or math skills, read books to their child, and talked about nature and/or engaged in science projects compared to parents in the 90th and 50th income percentile (Bassok, Finch, Lee, Reardon, & Waldfogel, 2016).

The importance of early childhood experiences has been regarded as "central to winning a lifelong educational and economic competition" (Bassok et al., 2016, p. 2). Douglas, Yoon, Tafur, and Diefes-Dux (2015) found that students in schools with a higher proportion of low-socioeconomic families (i.e., school Title I status) were less likely to have had learning gains in science and engineering content and less likely to have had a developed academic identity. Conversely, when examining identity development in the engineering context, students' exposure to STEM-integrated lessons supported this identity development (Douglas et al., 2015). The effect of being from a Title I school was no longer significant (Douglas et al., 2015). Douglas et al.'s study underscore the importance of having STEM-related experiences towards students' engineering identity development, at the elementary level, and the additional benefit experiences have on students from low-SES communities. In another study by Tolbert and Douglas (2016) using the same elementary student dataset and science and engineering content knowledge gains using pre- and post-tests found that on the pre-test, students from low-SES communities and racially ethnically diverse schools were likely to have had "less informal (outside of school) exposure to engineering" (p.10).

The impact parental involvement has on a student is also evident in the students' adolescent years (George & Kaplan, 1998). Harackiewicz and colleagues (2012) found that parents continue to play an important factor in their students' pursuits. Their study found that parents who were provided support on how to talk to their adolescent about the importance of mathematics and science course-taking in high school (i.e., experimental group) subsequently lead the adolescent to take more STEM courses compared to those in the control group (Harackiewicz et al., 2012). In a different study looking longitudinally at students from middle school to the transition into college found that parental level of education was predictive of taking mathematics and science courses in both high school and college, adding that course taking "reflect the critical choices they make about preparing themselves for STEM careers" (Svoboda, Rozek, Hyde, Harackiewicz, & Destin, 2016, p. 5).

Strutz and Ohland's (2012) study of eleven first-generation college students found that informal learning environments, interest, perception of who engineers are in society, advanced skillset in STEM subjects, and STEM-knowledgeable individuals encouragement and support were important factors towards fostering their intention to pursue engineering. The STEM-knowledgeable individuals cited by half of the first-generation college students were advanced placement or honors physics, chemistry, mathematics, and programming teachers (Strutz & Ohland, 2012). Stutz and Ohland (2012) emphasized how Julie, a chemical engineering student, was recognized, by her AP and honors chemistry teachers, as proficient and having a genuine interest in chemistry, "someone recognizing that I have a proficiency and … interest helped me … Otherwise, I wouldn't have noticed…" (p. 8). Likewise, first-generation college students in the study by Strutz (2012) noted the importance of STEM-talented friends, mostly in science and/or mathematics courses, as sources of influence towards their decision to pursue engineering. When examining the narrative of Kitatoi (whose story I will describe in Chapter 5 of this dissertation), I notice a commonality between Stutz and Ohland's (2012) participant Julie. Kitatoi, similar to Julie, was recognized as a capable mathematics type of person by a math teacher, which subsequently lead her on a path to mechanical engineering, she stated, "I feel like he [math director at community college] believed in me when I didn't, and I'm very grateful to him."

In another study of first-generation college students, when reflecting on their pre-college experiences, they cited tinkering with mechanical and electrical devices, participating in science competitions, writing computer programs, and talking about science with friends or family as out-of-school activities that supported their interest in STEM and recognition as individuals who can do STEM-related work (Verdín, Godwin, Sonnert, et al., 2018). Potvin et al. (2009) using data from college students enrolled in introductory biology, chemistry, and physics courses found that students who intended to pursue an engineering degree were more likely to have come from lower socioeconomic backgrounds, measured by parental' level of education, compared to other students interested in pursuing science careers.

The high school experiences students have are contingent on the resources and structures that are afforded to them. Not all students have equal access to resources. For example, the experiences afforded to well-funded high schools or students with family members knowledgeable of the college process are different from those offered to students who come from low-income neighborhoods or whose family members did not navigate through the college curriculum. A report documenting the National participation in Advanced Placement (AP) courses found that while there are more high schools that offer students college-level preparation, students who are low-income (identified using free-reduced lunch as a proxy) are three times less likely to be enrolled in these advanced preparatory courses (Theokas & Saaris, 2013). The literature based on first-generation college students often positions these students as disempowered or deficit-stricken individuals with little to negligible agency towards bettering their own lives. I step away from this perspective in favor of underscoring how first-generation college students enter engineering as capable agentic individuals; part of what it means to regard people as agentic "is to conceive of them as *empowered* by access to resources of one kind or another" (Sewell, 1992, p. 10; emphasis in original). I am not excusing the unequal access to resources for students in schools classified as underfunded compared to schools in affluent neighborhoods. Nor am I ignorant of the constraining environmental factors that students who are the first in their families to attend college are expected to navigate. Instead, I acknowledge that despite the unequal access and resources, first-generation college students are entering engineering programs having identified themselves as agentic engineering learners. Thus, to continue building an asset-based literature source about first-generation college students, I explore how these students, through their agency, come to see themselves as individuals that can do engineering.

4.4 Purpose of Study 2

First-generation college students' development of a disciplinary identity is a result of their exposure in their high school's curriculum as well as their experiences in and outside of the classroom. Often high school students who intend to major in a STEM field take the same mathematics and science courses in their pre-college education regardless of their future intended major. A lack of direct engineering experience makes the development of an engineering identity before college more difficult compared to other science and mathematics disciplines, such as biology or chemistry, which offer at least some direct, explicit experiences for students in high school (Fleming, Engerman, & Williams, 2006; Marra, Rodgers, Shen, & Bogue, 2012; Seymour, Hewitt, & Friend, 1997). Strides are being made to expose students to engineering-related content through the implementation of the Next Generation Science Standards (Moore, Tank, Glancy, & Kersten, 2015). Students develop interest, recognition, and performance/competence beliefs in activities situated in a given context (i.e., after-school environments, classrooms, museums, home activities, etc.). In this study, I measured first-generation college students' self-reported interest, recognition, and beliefs about being able to perform well and understand the subject material through survey items. This study examines how first-generation college students' personal agency supports their disciplinary role identities, how a mathematics and physics identity supports the development of an engineering identity, and how their personal agency and engineering identity empowers students to change their environment.

4.5 Background Information of Experiences from the Sample of First-Year First-Generation College Students Used in Study 2

The data used in this study came from the same national survey described in Chapter 3 for the development of the personal agency items. The CAREER survey instrument asked students a series of questions to understand some of the STEM experiences they had while in high school. Considering the assertions about the importance of AP courses and out-of-school experiences for students interested in pursuing STEM fields, I sought to understand if the experiences of the first-generation college student sample exemplified the experiences cited from prior work. Most first-year, first-generation college students (i.e., 85%) indicated they had not participated in Project Lead the Way; only 14% reported they participated in the program (with a 1% non-response rate). Additionally, from a list of STEM-related AP exams, the survey asked students to indicate the test score they obtained from a scale of one to five as used by the CollegeBoard. Most of the first-year first-generation college students reported they had not taken the AP exam from a list of STEM-related courses, as seen in Table 4.1. I found that the most common exam taken by the sample of first-year, first-generation college students was Calculus AB, with 160 (27%) students receiving a qualified score of 3 or higher. An important note to make here is the column in Table 4.1 titled "Did not take exam" represents a mixture of students who did not take the AP exam and were not enrolled in the AP courses listed.

I also sought to understand the people that contributed to the participants selecting an engineering career path. Students were allowed to choose from a list of family members, friends, STEM-related teachers, supportive adults (i.e., coaches, counselors, or engineering club leaders). Both mother and father were cited as nearly equally contributing to first-generation college students' choice of an engineering career path (55%, *n* = 327; 56%, *n* = 332 respectively). Additionally, first-generation college students' friends were the second highly referenced individuals' who supported the choice of selecting an engineering career (41%, *n* = 246). Only 30% (*n* = 180) students cited their mathematics teacher contributed to their selection of an engineering career; the percentage was fewer for physics, chemistry, biology teachers, and for any other adult (i.e., coaches, counselors, engineering club leaders).

Table 4.1. Results of First-Year First-Generation College Students STEM-Related Advanced Placement (AP) self-reported test scores

	Did not take exam	**Score of 1**	**Score of 2**	**Score of 3**	**Score of 4**	**Score of 5**
Calculus AB	365 (61.3%)	26 (4%)	44 (7%)	60 (10%)	54 (9%)	46 (7.7%)
Calculus BC	521 (88%)	4 (0.7%)	14 (2.3%)	17 (3%)	18 (3%)	21 (4%)
Physics B	525 (88%)	10 (1.5%)	20 (3%)	26 (7%)	11 (2%)	3 (0.5%)
Physics C	537 (90%)	2 (0.3%)	15 (3%)	12 (2%)	12 (2%)	17 (3%)
Env. Science	562 (94%)	2 (1%)	10 (0.3%)	9 (1.5%)	11 (2%)	1 (0.2%)
Computer Science	554 (93.1%)	6 (1%)	8 (1.3%)	14 (2.3%)	7 (1.2%)	6 (1%)
Biology	530 (89%)	3 (0.5%)	13 (2%)	26 (7%)	20 (3%)	3 (0.5%)
Chemistry	517 (87%)	9 (2%)	26 (7%)	29 (5%)	8 (1.3%)	6 (1%)
Statistics	535 (90%)	8 (1.3%)	10 (2%)	16 (3%)	19 (3.2)	7 (1.2%)

4.6 Theoretical Framework: Situating Critical Engineering Agency through Social Cognitive Theory

Critical engineering agency describes students' learning processes as (1) understanding engineering, (2) identifying oneself as someone with engineering habits of mind, (3) constructing and using engineering, and broadly STEM, in personally and socially meaningful ways, (4) imagining and constructing a socially just and equitable world, and (5) engaging in action that is personally and socially transformative (Basu et al., 2009; Godwin, 2014; Godwin & Potvin, 2017;

Godwin et al., 2016; Turner, 2012). Through a critical engineering agency perspective, students engage with engineering content in ways that are transformative for their lives and their broader community. Students take purposeful action towards counter-hegemonic pedagogical (i.e., educational) practices, with "the understanding that hegemony can be resisted through "counter-hegemony" or ... transformation of cultural domination into sites of revolution and social change" (Baez, 1999, p. 192). These frameworks provide a rich understanding of how students make sense of the personal and social identities they bring with them into engineering, how they develop an engineering identity, and how they use their critical engineering agency to change their lives, community, and the world around them.

Students' personal agency, in turn, influences their development of a disciplinary role identity. Identity development is not a passive endeavor; rather, identity is created, recreated, and sustained through participation in activities and reflexivity (Brickhouse & Potter, 2001; Roth et al., 2004). Developing an identity has been defined as "being recognized as a certain 'kind of person,' in a given context" (Gee, 2000, p. 99). An individual cannot be recognized as a certain kind of person unless she/he makes visible (performs) their competence in particular domains (e.g., mathematics, physics, and/or engineering; Carlone & Johnson, 2007; Cribbs et al., 2015; Hazari et al., 2010). An individual who takes on a role identity (e.g., being an engineer) adopts the meanings and expectations that accompany the specific role "and then act[s] to represent and preserve these meanings and expectations" (Stets & Burke, 2000, p. 227).

Disciplinary role identity in the critical engineering agency framework entails "the authoring of one's self within a particular context," a process that is "continually evolving [and] self-reflexive" (Godwin, 2014, p. 11). The authoring of one's self within the mathematics, physics, and engineering context is done through three interrelated constructs, interest, recognition, and performance/competence. An individual cannot be recognized as a certain kind of person unless he/she makes visible (*performs*) their *competence* in particular domains (e.g., mathematics, physics, or engineering; Carlone & Johnson, 2007). Gee (2001) noted that one's identity becomes an identity when "they are recognized by myself or others" (p. 102) in a particular context. Recognition is, therefore, both an external manifestation and an internal state, both of which are required for identity development (Carlone & Johnson, 2007; Potvin & Hazari, 2013). That is, how others perceive a person is an incomplete representation of how he/she sees themselves, it is also important to understand how a student internalizes these beliefs in shaping who they are and how they position themselves in the world (Godwin, Potvin, Hazari, & Lock, 2016; Potvin & Hazari, 2013). The last dimension of disciplinary role identity is interest in math, physics or engineering plays a key role in the framing of role identity. Interest involves a personal desire for learning and understanding in each context (Hazari et al., 2010). Scholars who study interest have found that learners who are interested in specific tasks "are likely to be able to self-regulate and persist to complete tasks even when they are challenged, whereas learners with little interest typically have difficulty engaging and continuing to work with tasks" (Renninger, Nieswandt, & Hidi, 2015, p. 2). Additionally, interest has been found to contribute to an individual's readiness towards identifying with a discipline (Godwin et al., 2016; Renninger & Hidi, 2016). Students' experiences that lead to interest, recognition, and beliefs about performing/understanding STEM content can be understood through Bandura's triadic model of reciprocal causation; an example is depicted in Figure 2.6 in Chapter 2.

Agency is intimately tied with identity; that is, the capacity individuals hold to make changes in their lives, and the world around them subsequently fosters identity development. Individuals display agency when constructing their identities, however, this construction process occurs within contextual constraints (i.e., communities of practice, structures, and/or sociohistorical legacies; Schwartz et al., 2011). However, students are not entirely free of being "whomever they want to be;" in the context of mathematics, physics, and engineering, authoring a disciplinary identity requires negotiation of "established meanings, expectations, and power relationships" (Shanahan & Nieswandt, 2011, p. 367). In addition to personal agency, Pickering (1995) posits that disciplines (like engineering) also have agency to help change the world. In my work, I connect disciplinary agency to the framework of critical engineering agency.

Engineering Agency Beliefs. Engineering agency beliefs refer to "students' perceptions of their ability to change their world through everyday action and their broader goals … [agency] involves how students see and think about STEM as a way to better themselves and the world" (Godwin & Potvin, 2015, p. 251). Agentic actions allow individuals to explore, maneuver, and impact their environment for the achievement of a goal or set of goals (Bandura, 2001). The result of an agentic behavior is a change or remake of one's environment (Bandura, 2001; Giddens, 1984; Holland et al., 1998). Agency beliefs encompass both disciplinary agency and personal agency. Agency in engineering is connected to students' feelings of empowerment, and this empowerment is tied to identity development (Godwin & Potvin, 2016). Additionally, agency in engineering is “intimately related to the leveraging and development of identity” (Basu et al., 2009, p. 356) to support the development of engineering engagement.

In the previous chapter, I outlined how I have developed new, more comprehensive measures of agency consistent with the origins of agency. This measure of personal agency consists of four cognitive activities,

- Intentionality: being purposeful, having a goal or action plan
- Forethought: foreseeing possible consequences or outcomes of one’s plan
- Self-reactiveness: ability to execute and monitor the goals or plans one has created
- Self-reflectiveness: internal learning process that involves examining and exploring past experiences or outcomes of goals to make informed decisions on future goals or action plans

Through the interaction of intentionality, forethought, reactiveness, reflectiveness an individuals’ agentic acts are realized.

4.7 Hypotheses

This study examines how first-generation college students enact their agency to develop disciplinary identities in the context of mathematics, physics, and engineering. I incrementally uncover how first-generation college students’ personal agency supports their disciplinary role identities, disposition towards seeking to change their environment through engineering, and the factors that foster an engineering identity. Specifically, I seek to prove the following hypotheses:

4.7.1 Hypothesis 1: I hypothesize the concept of engineering identity, physics identity, and mathematics identity will be supported by the latent constructs of interest, recognition, and performance/competence beliefs.

Rationale for H1. Prior work has established that interest and recognition serve as mediational effects onto performance/competence beliefs to the survey measures: “I see myself as an engineer” (Verdín, Godwin, Kirn, Benson, & Potvin, 2018a), “I see myself as a physics person” (Godwin et al., 2016; Verdín, Godwin, Sonnert, et al., 2018), and “I see myself as a math person” (Cribbs et al., 2015; Godwin et al., 2016). These mediational effects tell us how the three latent constructs sequentially influence one another and consequently influence the individual indicator; *I see myself as [ ]*. While I am not rejecting the mediational effects of prior work, I am establishing an alternative theoretical model structure in this study. The three latent constructs of interest, recognition, and performance/competence beliefs are intercorrelated and formulate a second-order construct of disciplinary role identities. This approach is different from other modeling work, specifically found in (Cribbs et al., 2015; Godwin, Potvin, et al., 2016; Potvin & Hazari, 2013; Verdín, Godwin, Kirn, Benson, & Potvin, 2019). However, creating a second-order latent variable for each disciplinary role identity makes explicit the hierarchical ordering of the factors (Schmid & Leiman, 1957). Further, it supports the theory that the three constructs inform the development of a disciplinary role identity. Prior work found the latent constructs of interest, recognition, and performance/competence beliefs were highly correlated (Cribbs et al., 2015; Godwin, 2016) and my analysis, in this study, also verified the constructs were correlated for this population (correlations ranging from .593 to .889). A second-order factor "tests a theory-based account for the patterns of relationships among the first-order factors … assert[ing] that second-order factors have direct effects on lower-order factors" (Brown, 2015, p. 339). The interrelationship of the three latent constructs justifies the rationale for testing a second-order latent construct (Brown, 2015; Rindskopf & Rose, 1988).

In a study examining first-generation college students' views of themselves as engineers in the foreseeable future (i.e., *I see myself as an engineer in the future)* and current views of themselves as engineers (i.e., *I feel like an engineer now*), found two conflicting results. Interest in the subject was more predictive of first-generation college students' views of their future possible selves. In contrast, interest was not predictive of their in the moment feelings of being an engineer (Verdín & Godwin, 2018b). Additionally, in the same study by Verdín and Godwin (2018b), beliefs about performing well and understanding engineering were not predictive of future identification as an engineer. In contrast, the same view of performance/competence beliefs was predictive of first-generation college students' current view of feeling like an engineer. While these findings may elicit conflicting results, what they are demonstrating is the impact of the temporal dimension of seeing oneself as an engineer and the impact specific questions (e.g., *I see myself as …*) have on the significance of interest, recognition, and performance/competence beliefs on first-generation college students' holistic understanding of their disciplinary identity. To consider the difference in how students see themselves in the present moment or the future and to consider that identity is continuously being shaped and reshaped through experiences, a second-order latent construct was more appropriate for this group of students. Therefore, I tested if the theoretical model of engineering identity, physics identity, and mathematics identity were supported by the latent constructs of interest, recognition, and performance/competence beliefs.

Additionally, second-order factors are usually more parsimonious models, that is, simple models with greater explanatory predictive power (Brown, 2015; Kline, 2016; Rindskopf & Rose, 1988). An example of second-order factor structures for each disciplinary role identity can be found in Figure 4.1. Establishing a reliable second-order latent construct for each disciplinary role identity allowed me to examine the proceeding hypotheses.

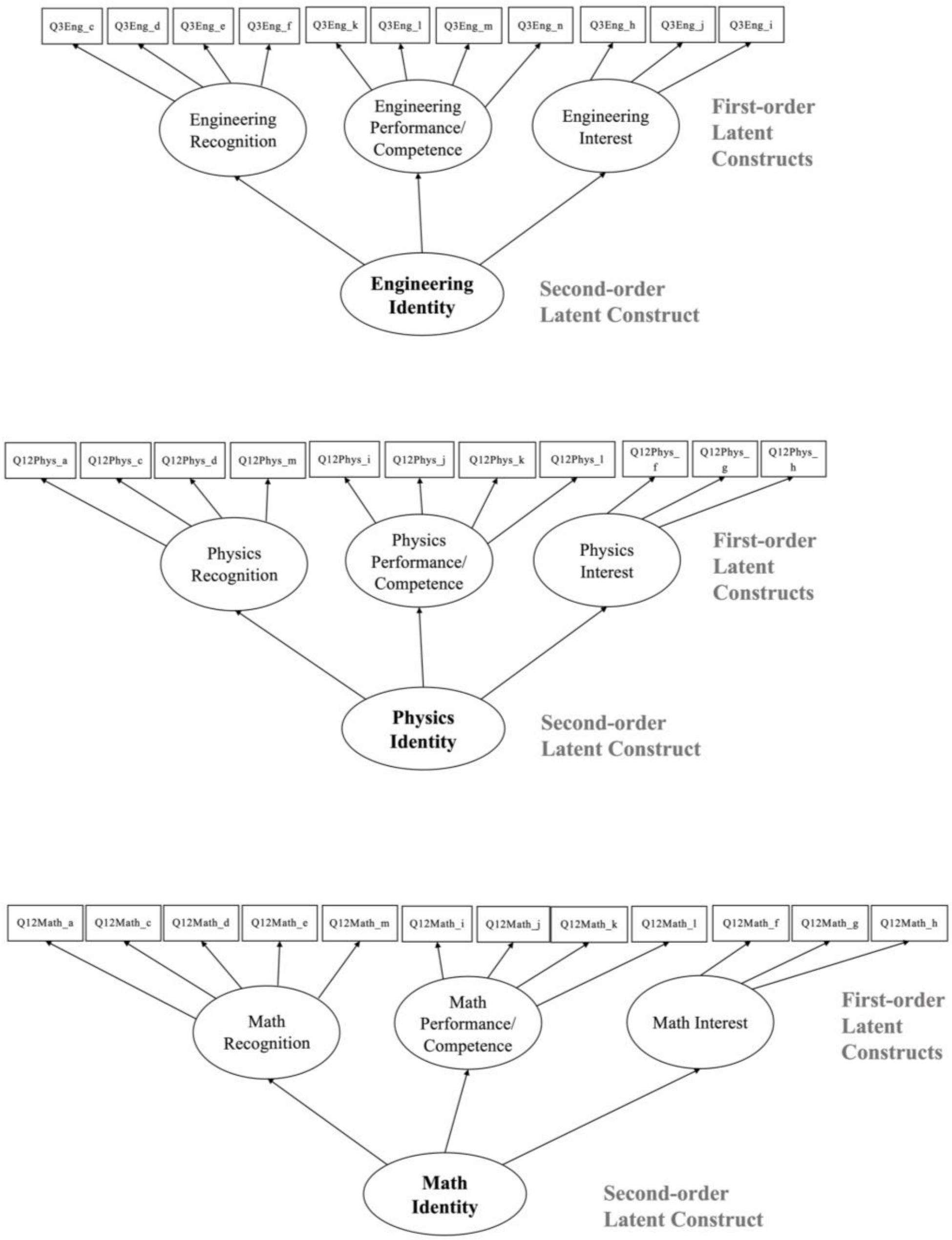


Figure 4.1. Example of hypothesized second-order latent construct for engineering identity, physics identity, and mathematics identity

4.7.2 Hypothesis 2: A mathematics identity will support the development of a physics identity and both will inform the development of an engineering identity.

Rationale for H2. A study of high school students ontological perspectives, i.e., what it means to be a person in a particular role, discussed those that who assume the role of a math type of person could also be a physics type of person (Verdín, Godwin, & Ross, 2018). In an earlier study, Shanahan and Nieswandt (2011) found that high school students reported those who are science type of people were also those with mathematics ability and interest, "Compared to other students, a science student is more likely to be good at math as well;" "When somebody's interested in science … they're usually more math or numbers oriented and smart that way"" (p. 379). Additionally, when high school students described who could assume the role of an engineer, a common understanding among students was, "you have to be a science person and a physics person and a math person to be an engineer because it kind of includes all three" (Verdín, Godwin, & Ross, 2018, p. 39). The messages students receive in high school about the types of people that can do math, science, physics, and engineering may influence the trajectories they take in college. Likewise, from prior studies we know that seeing oneself as a physics and math person supports the choice of an engineering major (Cass, Hazari, Cribbs, Sadler, & Sonnert, 2011; Cribbs, Cass, Hazari, Sadler, & Sonnert, 2016; Godwin et al., 2016; Verdín & Godwin, 2017a; Verdín, Godwin, Sonnert, & Sadler, 2018). This hypothesis expands the influence of how identifying as a physics and mathematics person supports the development of an engineering identity.

4.7.3 Hypothesis 3: Personal agency will have a direct influence on the development of students' mathematics, physics, and engineering identities.

Rationale for H3. First-generation college students' personal agency influences their engineering role identity because identity development is not a passive endeavor; rather, identity is created, recreated, and sustained through participation in activities and reflexivity (Brickhouse & Potter, 2001; Roth et al., 2004). Personal agency, theorized by Bandura (1986, 2001, 2006), is understood as students' realized capacity to exercise control over events that have an impact in their lives. Using personal agency to influence the environment is best illustrated by the narrative of Sam, a low-income first-generation college student in her first year as an engineering student. Sam, despite growing up constantly relocating homes, "depending on how rent was in the area," through her agentic capabilities situated herself in an environment, mathematics courses, where she thrived despite the structural constraints pressing against her personal agency; thus, allowing her to remake her environmental circumstances and create a path towards pursuing an engineering degree (Verdín & Godwin, 2019, p. 3). Hence, the capacity students hold to exercise control over events that affect their lives and the world around them subsequently fosters their perception of seeing themselves as STEM-type of people and as individuals who can enact change.

4.7.4 Hypothesis 4: Personal agency will support first-generation college students' disposition to use engineering as a tool towards making a difference in their community or world around them (i.e., engineering agency beliefs) and, in turn, will support the development of an engineering identity.

Rationale for H4. Students who are the first in their families to attend college are often positioned as passive recipients of their life's circumstances; I hypothesize that these students hold agentic capabilities and the desire to make a difference in the world around them (i.e., engineering agency beliefs). The work by Carlone and Johnson (2007), Ko et al. (2014), and Hodari, et al. (2013) describe how women in various science and engineering fields enacted their agency, taking direct action and ownership of their success amidst institutional and environmental barriers. One participant, in my Study 3 (next chapter), also emulates the disposition to make a difference in the world. Sam's family struggled financially (a structural constraint); she held a strong desire to enact her agency towards making a difference in the world. Her personal agency drove her to pursue a college degree, and when probed on how she became interested specifically in pursuing an engineering degree, stated,

> As I grew up, I saw all those [technological] changes. I just saw how that improved people's lives … I really was interested in engineering because it always involved some type of innovation. It involved all types of areas in people's lives, from construction to building roads to computers, even in medicine. Engineering takes part of everything. I really wanted to make an impact on an aspect of someone's life. Just motivation for making people's lives easier …

Through forward-directed planning and intentional goal setting, Sam positioned herself in an engineering program where she could enact her disposition towards making a difference not only in her life but in the lives of those around her through engineering. Through this positioning, Sam is not only enacting her personal agency for the achievement of a goal (i.e., using engineering to make people's lives easier) but through her engineering agency beliefs, she is establishing herself as someone that can use engineering, i.e., forming her identity in practice. A summary of the four hypothesized relationships can be found in Figure 4.2.

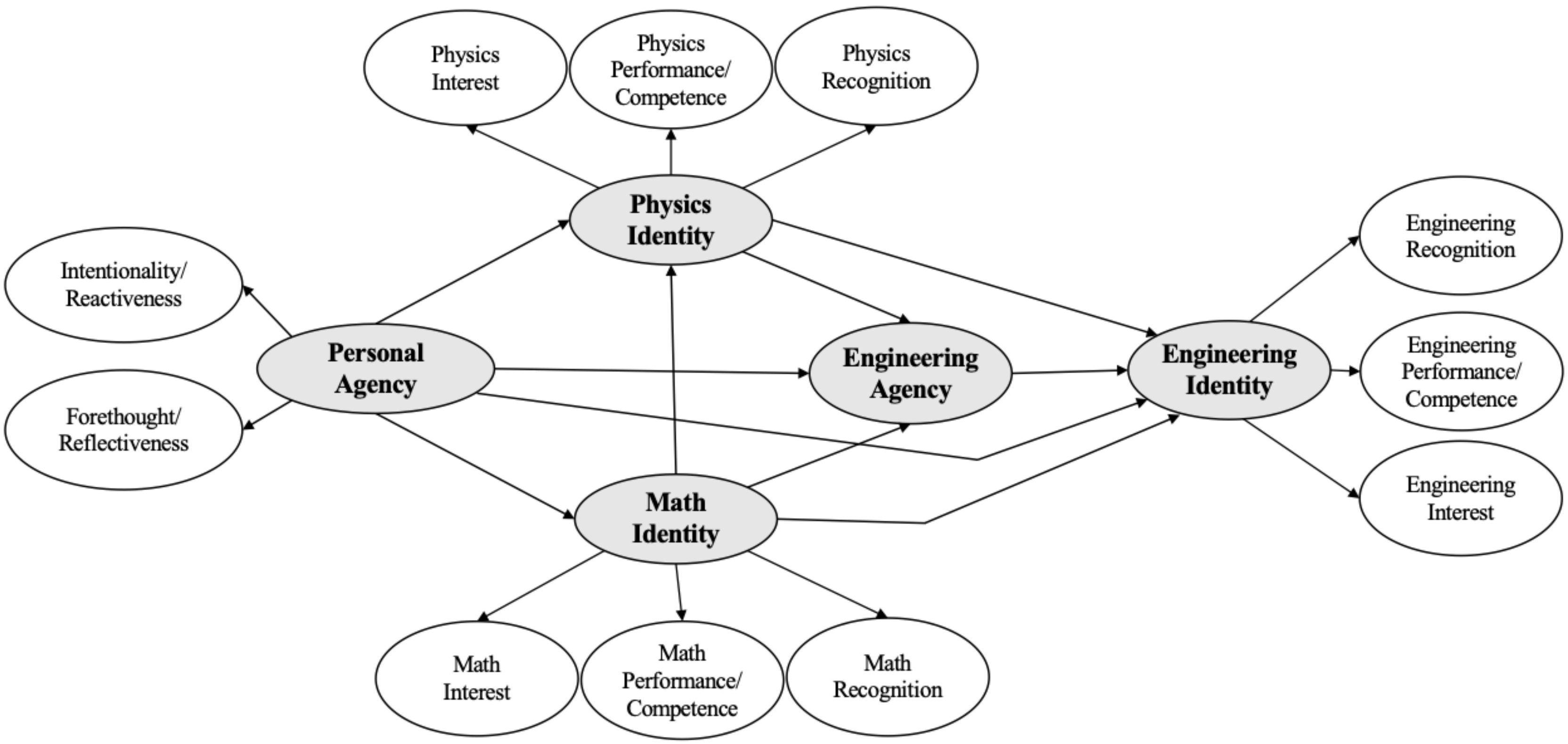


Figure 4.2. Hypothesized Relationships Between Personal Agency, Engineering Agency, Disciplinary Role Identities

4.8 Dataset for Analysis

4.8.1 Data Source

Data for this analysis came from the study, CAREER: Study of Students' Underlying Attitudes and Beliefs in Engineering (NSF 1554057). A nationally representative survey was deployed in the first weeks of the Fall 2017 semester. A sample of 3,711 first-year engineering students in 32 four-year ABET-accredited institutions was obtained. To obtain this sample, a stratified random cluster sampling technique was utilized, that is, schools were divided based on the number of engineering students enrolled by small (7,750 or less), medium (7,751 to 23,050), and large (23,051 or above) based on the National Center for Education Statistics Integrated Postsecondary Database System (U.S. Department of Education & Institute of Education Sciences National Center for Education Statistics). Students who responded that their parent/guardian level of education is "less than a high school diploma," "high school diploma/GED," or "some college or associate/trade degree," were coded as first-generation college students (FGCS). While students who responded that their parent/guardian level of education for either parent/guardian as having a "bachelor's degree" or "master's degree or higher," were coded as continuing-generation college students (CGCS). Students that did not report their parent's education level or who are coded as CGCS were not included in this study. This analysis will only focus on FGCS; therefore, only a subset of the data was used.

While I intentionally targeted first-year engineering programs, the overall sample of first-generation college students also consisted of second, third, fourth-year students, see Table 4.2. In this study, I only focused on students who were in their first year in college and are the first in their families to attend college. The purpose of only focusing on first-year students was to understand how their engineering identity is shaped prior to engaging in engineering or college coursework. My sample of first-year, first-generation college students was $n_s = 595$. Demographic information of these students can be found in Table 4.3.

Table 4.2. Breakdown of First-Generation College Students, from our dataset, by the number of years they have been in college

What year are you in college?	Number of students
First-Year	595
Second-Year	104
Third-Year	50
Fourth-Year or Higher	12
Total Number of First-Generation College Students in the dataset	**840**

Table 4.3 Summary of Demographic Information of First-Year First-Generation College Students

Race/ Ethnicity	Total+	Female	Male
Asian	82	23	59
Black or African American	46	14	32
Latino/a or Hispanic	116	24	92
Middle Eastern or Native African	12	3	9
Native Hawaiian or another Pacific Islander	4	1	3
Native American or Alaska Native	9	4	5
White	369	90	279
Another race/ ethnicity not listed above	12	4	8
Sample Total	595++	141	455

Note. Students who respond their parent/guardian level of education is "less than a high school diploma," "high school diploma/GED," or "some college or associate/trade degree," were coded as first-generation college students.

+Students were allowed to choose multiple race/ethnicities as they identified, for example, 13% of students in the White category also identified with another race/ethnicity.

++Sample reflects the actual sample size of the first-year first-generation college students surveyed

4.8.2 Survey Measurement used in Study 2

For the items used in this study, students were asked to evaluate, "To what extent do you agree or disagree with the following statements?" using a 7-point anchored numeric scale, ranging from "0-Strongly disagree" to "6-Strongly agree." Students were asked to rate the extent to which they agreed or disagreed with statements about interest, recognition, and performance/competence in engineering. Prior work has established strong validity evidence for the latent constructs used in this analysis (i.e., engineering identity measures [Godwin, 2016; Verdín, Godwin, Kirn, Benson, & Potvin, 2018], physics identity measures [Godwin, Potvin, Hazari, & Lock, 2013; Godwin, Potvin, et al., 2016; Hazari et al., 2010; Potvin & Hazari, 2013], mathematics identity measures [Cribbs et al., 2016, 2015; Godwin, Potvin, et al., 2016], and personal agency [see Chapter 3 and Verdín & Godwin (2019)]). All survey measured used in this study can be found in Appendix E.

4.8.3 Data Analysis Procedure

The method of analysis used was structural equation modeling, as it allows for relationships to be tested in a specified order. Similar to CFA, this method examines the fit of a measurement model before testing connections between latent variables (i.e., the structural model). Before conducting structural equation modeling, I followed five data analysis procedures, 1) checking for assumptions of univariate and multivariate normality, 2) examining the measurement model through confirmatory factor analysis, 3) examining measurement invariance across men and women, 4) examining structural invariance across men and women, 5) examining the overall model fit, and outlined in Figure 4.3.

The confirmatory factor analysis was run using the *cfa* function found in the lavaan package in the R statistical programming environment (Rosseel, 2012). The structural equation model and measurement invariance test were run using the *sem* function found in the lavaan package (Rosseel, 2012). All analyses was conducted in R statistical programming software version 3.5.3 (R Core Team, 2018).

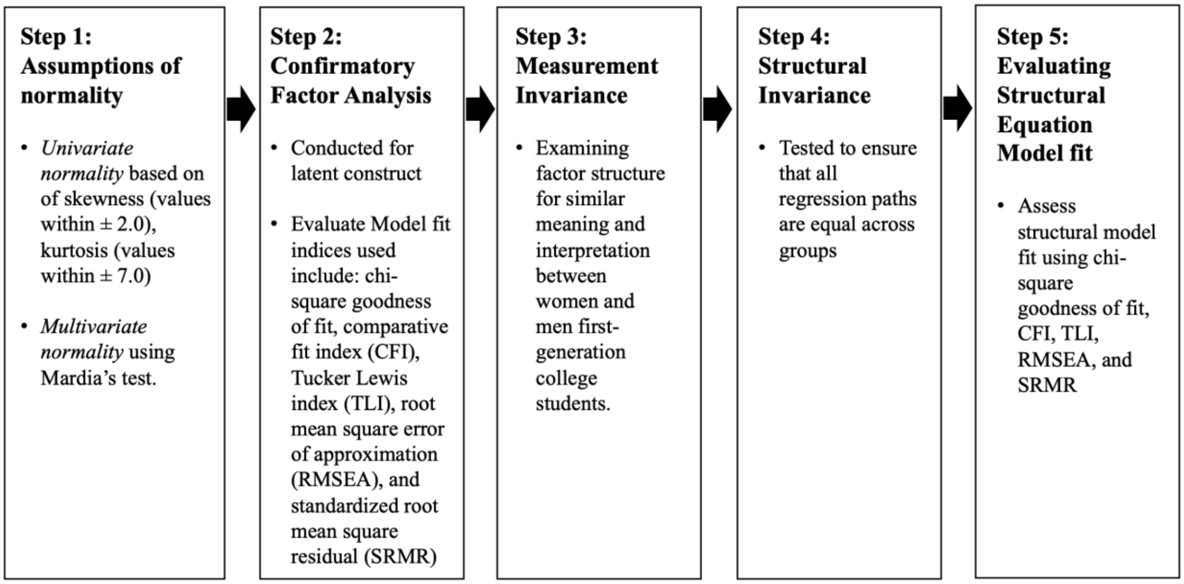


Figure 4.3. Roadmap for data analysis procedure

4.8.4 Step 1: Assumptions of Normality

Data were screened to verify assumptions of univariate and multivariate normality through skewness, kurtosis, and Mardia's Test. The univariate normality recommended cut-off values for sample sizes larger than 300 participants are: skewness should range between –2 to 2 and kurtosis should range from –7 to 7 (Fabrigar et al., 1999; West, Finch, & Curran, 1995). Multivariate normality was examined using Mardia's Test (Korkmaz et al., 2014). Determining whether data were univariate and multivariate normal is important in order to select an estimator and test statistic with robust standard errors. Lastly, construct reliability were examined using Cronbach's alpha which recommends that constructs should be higher than 0.70 (Tavakol & Dennick, 2011)

4.8.5 Step 2: Evaluating Confirmatory Factor Analysis for Measurement Model

Results of the confirmatory factor analysis were evaluated based on three categories of fit indices: 1) absolute fit, 2) fit adjusting for model parsimony, and 3) comparative fit. Absolute fit determines the model fit at an absolute level, which is 'perfect' fit. The absolute fit examines at Chi-square and standardized root mean square residual (SRMR). The SRMR is understood "as the average discrepancy between the *correlations* observed in the input matrix and the correlations predicted by the model" (Brown, 2015, p. 82). SRMR falls between 0.0 to 1.0, where 0.0 would indicate perfect fit. To test for parsimony, the and root mean square error of approximation (RMSEA) is a widely recommended index, it is an "error of approximation" index because it determines how well the model fits within the population (Brown, 2015; Steiger & Lind, 1980). A close fit would indicate the RMSEA is less than or equal to 0.05 and less than or equal to 0.08 would indicate a moderate fit (Brown, 2015; Maccallum et al., 1996). Comparative fit index (CFI) "evaluates the fit of a user-specified solution in relation to a more restricted, nested baseline model" and has a range of 0.0 to 1.0, where 1.0 implies good model fit (Brown, 2015, p. 84). Lastly, the Tucker Lewis Index (TLI), another comparative fit index, should have acceptable values above 1.0 (Brown, 2015).

Prior work has established construct reliability and validity, using exploratory and confirmatory factor analysis, for the mathematics, physics, and engineering identity latent variables (Cribbs et al., 2015; Godwin, 2016; Godwin, Potvin, et al., 2016). The studies by Verdín et al (2018), Verdín et al. (2018b), and Verdín et al. (2019) established reliability and validity for physics and engineering identity measures using a sample of first-generation college students. The analysis for this study went as follows. First, individual confirmatory factor analysis was conducted for the latent constructs: engineering identity, physics identity, mathematics identity, and engineering agency beliefs. The process for conducting a confirmatory factor analysis was similar to that described in Chapter 3. Therefore, a CFA for these constructs will not be described in this study. However, a final measurement model for all latent constructs was conducted concurrently for all measured variables in order to build a structural model. This process was necessary for checking the behaviors of previously studied items for the sample used in this study.

4.8.6 Step 3: Measurement Invariance

After establishing that the model fit was acceptable, a measurement invariance test was conducted to determine if women and men conceptualized the constructs of disciplinary role identities, personal agency, and engineering agency similarly. Four levels of measurement invariance were tested, configural (Model 1), metric (Model 2), scalar (Model 3), and strict invariance (Model 4) using a chi-square difference test. Testing for measurement invariance is a prerequisite to testing structural coefficients across groups (Millsap & Meredith, 2007; Sass &

Schmitt, 2013). Below, I briefly describe the implications when testing for configural, metric, scalar, and strict invariance for interpreting measurements and differences between groups. A thorough examination of measurement invariance with a similar engineering population can be found in my prior published work (Verdín & Godwin, 2017b).

Configural invariance (Model 1), after specifying the model using CFA, this test examines if the model specified (i.e., factor structure) is equal across groups (Brown, 2015, pp. 242–243). I first specified the factor structure for all three disciplinary role identities, engineering agency beliefs, and the two constructs for personal agency (i.e., intentionality/reactiveness and forethought/reflectiveness). Once it is established that the basic structure of the model holds for both groups (i.e., males and females), testing for metric invariance (equivalence of factor loadings across groups) can be conducted (Brown, 2015; Kline, 2016).

Metric invariance (Model 2) tests whether respondents across groups attribute the same meaning to the latent constructs under study (i.e., interest, recognition, and performance/competence beliefs). Testing for metric invariance uses a chi-square difference test to establish if constraining the factor loadings to be equal across the multiple groups corresponds with a significant increase in chi-square. If there is a difference in chi-square, then there is a factor loading that is not equal across groups (Kline, 2016).

Scalar invariance (Model 3) examines the equality of intercepts between engineering identity scores across groups. Scalar invariance suggests that different groups respond to the scale (seven-point anchored numeric scale) in the same way (Kline, 2016). Rejecting scalar invariance would suggest that group differences in estimated factor means are biased and that group differences from the mean (generated from the measurement scale) or the estimated factor scores will not be directly related to the factor means and will be distorted by differential additive response styles (Gregorich, 2006; Kline, 2016). A differential additive response style "occurs when one group systematically gives higher or lower responses than another group, resulting in a scale displacement" (Cheung, Rensvold, Cheung, & Rensvold, 2000, p. 190). Differential additive bias will inevitably make the mean differences of the observed variables smaller or larger than their true mean difference or will indicate no difference when a difference exists (Brown, 2015; Kline, 2016). However, if scalar invariance is established, groups can be compared to their scores on the latent variable.

The last measurement invariance tested is strict invariance (Model 4). Strict invariance assumes there is scalar invariance and tests for equality in error variances and covariance across genders. This test examines if the residual, uniqueness or measurement errors associated with each survey question are equal across males and females (Gregorich, 2006). In practice, some scholars argue that strict invariance does not need to be tested since it may be unreasonable to assume that random error variance should be equal across groups (Hox, De Leeuw, & Zijlmans, 2015; Kline, 2016). There seems to be disagreement among the research community as to the importance of including strict invariance. For example, Little (2013) states, "I strongly recommend that strict factorial invariance not be imposed when doing any kind of comparisons across time (or groups)" (p. 143). I have chosen to test for strict invariance with the understanding that I don't need to enforce this equivalence tests (Little, 2013).

Configural invariance must be reached to move forward and ethically conduct a group comparison. However, if the chi-square is significant at the metric (Model 2), scalar (Model 3) or strict (Model 4), partial invariance can still be established by identifying any parameters that are causing nonequivalence in the model and allowing those parameters to be estimated independently (Bryne, Shavelson, & Muthén, 1989).

4.8.7 Step 4: Structural Invariance

After examining whether the model has measurement invariance, the next step is to test the structural invariance portion of the model, determining if the regression paths are equivalent across groups. The structural part of the model allows relationships between latent variables to be tested and a final structure, based on theory, to be analyzed. Structural invariance was tested by constraining all the structural parameters to be equal across groups and evaluating whether there was a change in the model fit by observing a change in chi-square (Sass & Schmitt, 2013). Any parameter that is found to be variant across, both for the measurement and structural tests, will be freely estimated using the *group.partial* function in the lavaan package (Rosseel, 2012).

4.8.8 Overall Structural Equation Model Fit

The purpose of structural equation modeling (SEM) is to test the degree to which various theoretical models are supported by the sampled data (Schumacker & Lomax, 2016). The structural portion of the model allows relationships between latent variables to be tested and a final structure, based on theory, to be analyzed. Overall structural equation model fit should be evaluated after establishing measurement and structural invariance. To assess model fit indices chi-square goodness of fit, comparative fit index (CFI; acceptable values above 0.9 (Bentler, 1990)), Tucker Lewis index (TLI; acceptable values above 0.9 (Bentler, 1990)), root mean square error of approximation (RMSEA; values less than 0.08 indicate moderate fit (Browne & Cudeck, 1993)), and standardized root mean square residual (SRMR; acceptable value is less than 1, where 0.0 would indicate perfect fit (Brown, 2015; Hu & Bentler, 1999)). It is known that the chi-square goodness of fit test is sensitive to large sample sizes ($n > 200$); nevertheless, this is a commonly reported index in SEM analysis (Brown, 2015; Kline, 2016; Lomax & Schumacker, 2004).

4.9 Results of Data Analysis

In the subsections that follow, I summarize the results of the five data analysis procedures.

4.9.1 Assumptions of Normality

Skewness and kurtosis were examined, no single measure violated the univariate normality acceptable range values within ± 2.0 for skewness or values within ± 7.0 for kurtosis for data with a sample size greater than 300 (West et al., 1995). Mardia's test for multivariate normality revealed our data was not multivariate normal, multivariate skewness $\gamma_{1,p}$ = 1074.55.83, $p < .000$ and estimates of multivariate kurtosis $\gamma_{2,p}$ = 5497.27, $p < .000$. Micceri's (1989) work evaluating real-world psychometric distributions found that non-normality is common. However, given the outcome of the multivariate normality test, a Satorra-Bentler ($SB\chi^2$) mean adjusted test statistic will be reported to account for non-normality in the distributions (Satorra & Bentler, 2010). Additionally, a robust maximum likelihood (MLM) estimator will be used. MLM corrects for both the model chi-square and the standard errors of the parameter estimates for deviations from a normal distribution (Brown, 2015; Satorra & Bentler, 2001).

4.9.2 Evaluation of Confirmatory Factor Analysis

A confirmatory factor analysis was run to examine the measurement model fit. The Satorra-Bentler adjusted chi-square test for goodness of fit was $SB\chi^2 = 1874.23$, $df = 1013$, $p < .000$. A significant Satorra-Bentler chi-square goodness of fit is not uncommon, as chi-square tests tend to be sensitive to large sample sizes (Lomax & Schumacker, 2004). The remaining fit indices were CFI of 0.93, TLI of 0.93, RMSEA of 0.04 with a 90% confidence interval of (0.04, 0.05), and an SRMR of 0.05. Overall, the fit indexes suggest a good model fit.

All standardized factor loadings were well above the 0.45 minimum cut off values (Tabachnick & Fidell, 2013). Indicator reliability, evaluated by individually squaring the standardized factor loadings, were above 0.50, demonstrating that each item measured above 50 percent of the true-score variance (Brown, 2015). The construct reliability, evaluated using Cronbach's alpha, were between 0.86 to 0.93, which are above the recommended alpha value of 0.70, indicating good construct reliability (Tavakol & Dennick, 2011). The amount of variance captured by each construct was greater in relation to the amount of variance due to measurement error, i.e., variance was above 0.50 (Fornell & Larcker, 1981). All AVE values were above the recommended 0.50 value indicating the constructs have convergent validity. A summary of all factor loadings, item reliability, construct reliability, and average variance extracted can be found in Table 4.4.

Table 4.4. Summary of first-order latent constructs used in confirmatory factor analysis

Latent Construct	Indicators	+Std factor loadings	Item reliability	Construct reliability	Average variance extracted
Math Recognition				0.85	0.58
	Q12Math_a = I see myself as a math person.	0.818	0.666		
	Q12Math_d = My peers see me as a math person.	0.747	0.558		
	Q12Math_e = I've had experiences in which I was recognized as a math person.	0.727	0.845		
	Q12Math_m = Others ask me for help in math.	0.750	0.563		
Math Interest				0.88	0.72
	Q12Math_f = I am interested in learning more about math.	0.812	0.659		
	Q12Math_g = I enjoy learning math.	0.912	0.832		
	Q12Math_h = I find fulfillment in doing math.	0.809	0.654		
Math Performance/ Competence				0.92	0.75
	Q12Math_i= I am confident that I can understand math in class.	0.882	0.780		
	Q12Math_j = I am confident that I can understand math outside of class.	0.868	0.753		
	Q12Math_k = I can do well on exams in math.	0.825	0.681		
	Q12Math_l = I understand concepts I have studied in math.	0.874	0.764		

Physics Recognition			0.86	0.62
Q12Phys_a = I see myself as a physics person.	0.745	0.555		
Q12Phys_c = My instructors see me as a physics person.	0.824	0.679		
Q12Phys_d = My peers see me as a physics person.	0.801	0.642		
Q12Phys_m = Others ask me for help in physics.	0.776	0.602		
Physics Interest			0.90	0.77
Q12Phys_f = I am interested in learning more about physics.	0.844	0.712		
Q12Phys_g = I enjoy learning physics.	0.936	0.876		
Q12Phys_h = I find fulfillment in doing physics.	0.860	0.740		
Physics Performance/Competence			0.94	0.79
Q12Phys_i= I am confident that I can understand physics in class.	0.908	0.824		
Q12Phys_j = I am confident that I can understand physics outside of class.	0.877	0.769		
Q12Phys_k = I can do well on exams in physics.	0.878	0.771		
Q12Phys_l = I understand concepts I have studied in physics.	0.897	0.805		
Engineering Interest			0.91	0.78
Q3Eng_i = I enjoy learning engineering.	0.919	0.845		
Q3Eng_j = I find fulfillment in doing engineering.	0.886	0.785		

	Q3Eng_h = I am interested in learning more about engineering.	0.841	0.707		
Engineering Recognition				0.82	0.55
	Q3Eng_c = I see myself as an engineer.	0.711	0.506		
	Q3Eng_d = My parents see me as an engineer.	0.684	0.468		
	Q3Eng_e = My instructors see me as an engineer.	0.734	0.539		
	Q3Eng_f = My peers see me as an engineer.	0.821	0.674		
Engineering Performance/Competence				0.90	0.69
	Q3Eng_k = I am confident that I can understand engineering in class.	0.872	0.760		
	Q3Eng_l = I am confident that I can understand engineering outside of class.	0.817	0.667		
	Q3Eng_m = I can do well on exams in engineering.	0.809	0.654		
	Q3Eng_n = I understand concepts I have studied in engineering.	0.821	0.674		
Engineering Agency Beliefs				0.92	0.69
	Q5c = Engineering will give me the tools and resources to make an impact in my community.	0.854	0.729		
	Q5d = Engineering can improve quality of life.	0.765	0.585		
	Q5e = Engineering can be a resource for my community.	0.872	0.760		
	Q5f = I can make an impact in peoples' lives through engineering.	0.761	0.579		
	Q5g = Engineering can improve the quality of life in my community.	0.871	0.759		

Intentionality/Reactivity			0.90	0.65
Q8b = I monitor my actions to achieve my goals.	0.776	0.602		
Q8e = I set goals that are achievable.	0.821	0.674		
Q8f = I keep myself motivated to reach my goals.	0.807	0.651		
Q8g = My plans become actions.	0.797	0.635		
Q8j = I actively keep myself on track to complete my plans.	0.813	0.661		
Forethought/Reflection			0.88	0.64
Q8l = I reflect on my actions to see if I could have made improvements.	0.813	0.661		
Q8m = I anticipate potential consequences when making plans.	0.709	0.503		
Q8n = I think about my experiences to improve on my next performance.	0.847	0.718		
Q8o = I think over what I have done to consider alternative ways of doing it.	0.820	0.672		

Note. [+] All standardized factor loadings are significant at the $p > .001$

4.9.3 Step 3: Measurement Invariance

Results indicate scale invariance (model 3) does not hold and some intercepts need to be freely estimated across groups. After examining intercepts that had the highest expected chi-square parameter change and re-testing the change in model fit, I found that five intercepts might need to be freely estimated. Lastly, strict invariance was tested against the partial scalar invariance model; the chi-square difference tests indicated that the models were significantly different indicating a need to freely estimate eight residual error variances (achieving partial strict invariance)—see Table 4.5 for a summary. Again, there is a general disagreement between enforcing strict invariance. I decided to freely estimate the eight residual error variances in my model. Once the residual error variances were freely estimated the baseline model was compared to the modified model, the scaled chi-square difference test yield a non-significant change ($\Delta\chi^2(133) = 157.85$, $p = .070$).

Table 4.5. Summary of measurement invariance of latent constructs used in the model

Measurement Invariance Models	**Model Comp.**	χ^2_{SB} (df)	**CFI**	**RMSEA (90%CI)**	$\Delta\chi^2_{SB}$ (Δdf)	p	**Freely estimated parameters**	**Decision H0**
Model 1: Configural Invariance	-	4084.3 (1852)	0.93	0.06 (0.05, 0.06)	-	-	-	-
Model 2: Metric Invariance (loadings)	1 vs. 2	4180.7 (1821)	0.93	0.05 (0.05, 0.06)	70.73 (56)	.089	-	Accept
Model 3: Scalar Invariance (loadings + intercepts)	2 vs. 3	4247.8 (1937)	0.92	0.06 (0.05, 0.06)	163.44 (29)	.000	-	Reject
Model 3b: Partial Scalar Invariance (loadings + intercepts + freely estimated)	2 vs. 3b	4200.8 (1931)	0.93	0.05 (0.05, 0.06)	23.27 (23)	.445	Q3Eng_m, Q3Eng_n, Q12Phys_a, Q12Phys_d, Q12Phys_f	Accept
Model 4: Strict Invariance (loadings + intercepts + residuals)	3b vs 4	4461.1 (1976)			133.21 (45)	.000	-	Reject
Model 4b: Strict Invariance (loadings + intercepts + residuals + freely estimated)	3b vs 4b	4267.5 (1965)			35.05 (34)	.418	Q12Phys_f, Q12Math_e, Q12Math_l, Q12Math_k, Q8m, Q5d, Q8f, Q5f	Accept

4.9.4 Structural Invariance

Five intercepts and eight residual error variances were freely estimated across groups to achieve partial measurement invariance. Establishing partial measurement invariance allowed me to then test the structural portion of the model, which determines if the regression paths are equivalent across groups. Model 4b was compared against the structural model resulting in a non-significant change in the chi-square difference test ($\Delta\chi^2(10) = 7.48$, $p = .679$).

4.9.5 Overall Structural Equation Model Fit

After establishing measurement and structural invariance, the final structural model fit Satorra-Bentler adjusted chi-square test for goodness of fit was $SB\chi^2 = 3009.12$, $df = 2159$, $p < .000$. The fit indexes were CFI of 0.91, TLI of 0.91, RMSEA of 0.048 with a 90% confidence interval of [0.045, 0.051], and an SRMR of 0.072. Overall, the fit indexes suggest a good overall model fit (Hooper, Coughlan, & Mullen, 2008; Kline, 2015). Figure 4.4 shows the structural equation model with significant paths.

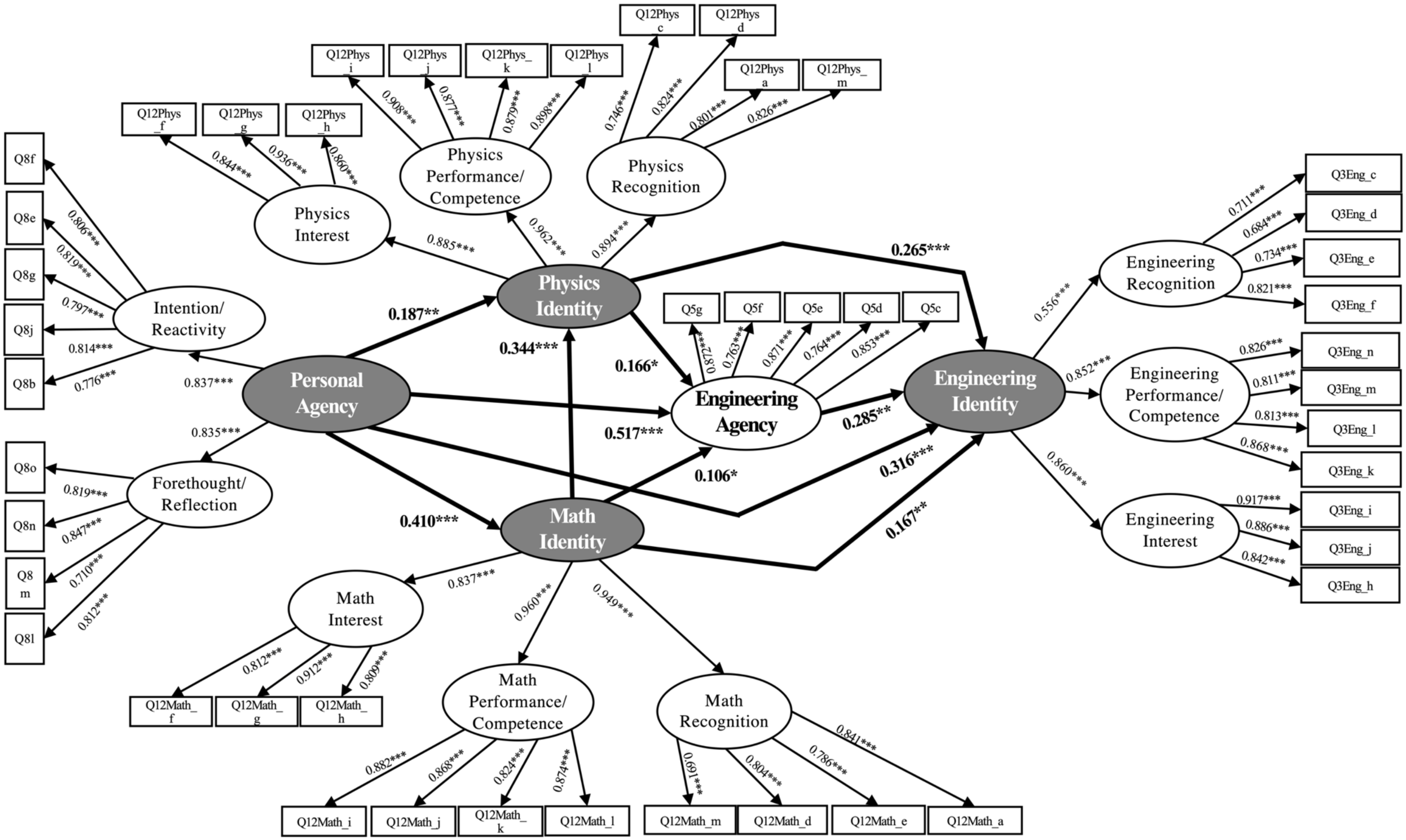


Figure 4.4. All factor loadings are significant at the *p* > .001 level. Significance of *p*-values for regression paths are denoted as * *p* < .05; ** *p* < .01; *** *p* < .001. The exact survey questions associated with the indicators (represented as square boxes) can be found in Table 4.4. Second-order latent variables are highlighted in gray

4.10 Discussion of Findings

4.10.1 H1. Disciplinary role identities can be specified as second-order structures

Three second-order factor structures were tested (i.e., mathematics identity, physics identity, and engineering identity). The results of the analysis support the theoretical standpoint that the multidimensional constructs of interest, recognition, and performance/competence beliefs all support the underlying latent variable of engineering, physics, and mathematics identity. Modeling the disciplinary identities as a second-order latent construct allowed me to understand which construct explains more variance in the overarching identity factor structures. I found that the second-order latent construct of mathematics identity, math performance/competence beliefs had the highest factor loading of 0.960, followed by math recognition with a factor loading of 0.949, and math interest with a factor loading of 0.837. Students tend to be exposed to mathematics content for a longer period of time, thus gaining more confidence in their abilities to understand the subject and be afforded more opportunities to be recognized as mathematics type of people. When examining the second-order latent construct of physics identity, physics performance/ competence beliefs had the highest factor loading of 0.962, following physics recognition and interest having factor loadings of 0.894 and 0.885, respectively. Physics is offered as a formal course in high school, albeit in the last years of students' high school pathway; nonetheless, the factor loadings demonstrate the importance of first-generation college students' perceptions of themselves as capable learners (i.e., understanding and performing well) of physics. Lastly, I examined the second-order latent construct of engineering identity and found that engineering interest had the highest factor loading of 0.860, following engineering performance/ competence beliefs 0.852, and engineering recognition 0.556. While efforts are being made to incorporate engineering content into the K-12 curricula (see Moore, Tank, Glancy, & Kersten, 2015; NGSS Lead States, 2013) there are still concerns about how engineering content is represented, that is as an isolated course versus as a support towards science instruction (Purzer, Moore, Baker, & Berland, 2014). Given the current state of engineering education in students' pre-college education, it is not surprising that first-generation college students are displaying slightly more interest in engineering as opposed to physics and mathematics. Lastly, being recognized as someone that can do engineering currently has the lowest effect on first-generation college students' engineering identity, perhaps because these students have not had formal spaces where they can perform their capabilities as individuals that can do engineering. An ad hoc descriptive analysis of first-generation college students' response to the question, "Have you participated in Project Lead the Way?" revealed that the majority of the first-generation college students sampled in the CAREER dataset (85%) did not have this experience in high school.

Establishing a reliable second-order latent construct for each disciplinary role identity allowed me to move forward and examine the other hypotheses in this study.

4.10.2 H2. A mathematics identity will foster the development of a physics identity and both will support the development of an engineering identity

I hypothesized that first-generation college students' beliefs of seeing themselves as mathematics type of people would help inform their development of a physics identity. The results supported this hypothesis; specifically, a mathematics identity had a direct effect on first-generation college students' physics identity ($\beta = .344$, $p < .001$). Seeing oneself as a capable mathematics learner has a direct and indirect effect on first-generation college students' formation of an engineering identity. A mathematics identity has a direct effect on students engineering identity ($\beta = .167$, $p < .01$), albeit the impact of a mathematics identity was three times more influential on students' physics identity. First-generation college students' perceptions of themselves as competent and interested mathematics learners and recognized by others as a mathematics type of person, consequently supported their views of themselves as capable physics and engineering learners. Seeing oneself as a capable physics learner had twice as much of a direct effect in supporting the development of an engineering identity for first-generation college students ($\beta = .265$, $p < .001$) compared to a mathematics identity. Similar findings can be seen in a study examining students' likelihood of choosing a career in engineering, seeing oneself as a physics type of person had twice as much of a direct effect than seeing oneself as a math type of person (Godwin et al. 2016).

Seeing oneself as a mathematics type of person supported first-generation college students' perceptions of seeing themselves as physics type of people. Physics identity has also been shaped through experiences both in and out of the classroom. My prior work on first-generation college students found that out-of-school activities such as tinkering with mechanical devices, participating in science/math competitions, and engaging in conversations about science with friends or family members supported their interest and recognition as someone that can be a physics type of person (Verdín, Godwin, Sonnert, et al., 2018). Similarly, Hazari et al.'s (2010) study, albeit not focused exclusively on first-generation college students, found that pedagogical practices such as discussions about the relevance of science to everyday life, conversations about taking on a science identity, and encouragement to participate in science courses were positive predictors of developing a physics identity in high school. Thus, these experiences foster the development of disciplinary role identities. My current study of first-generation college students found that their perceptions of being capable physics learners (i.e., performance/competence beliefs) had the highest support on their physics identity. When examining if my sample of students participated in physics before college, an overwhelming majority indicated having some type of exposure, and 85% had either taken a regular physics course, honors, AP, IB, or another advanced type of physics course. Exposure to these courses for the students in this sample could have supported their claims of being both internally and externally recognized as physics type of people.

Disciplinary role identity, specifically in mathematics and physics is an important factor in pursuing an engineering career (Cribbs et al., 2016; Godwin, Potvin, et al., 2016) and students' development of a disciplinary role identity is a result of exposure to course material inside and outside of the classroom (Aschbacher, Li, & Roth, 2010; Carlone, 2004; Verdín, Godwin, Sonnert, et al., 2018). For example, Warne and colleagues (2019) found that students who had taken AP Calculus had a higher career interest in engineering; perhaps exposure to advance mathematics content supported students' mathematics identity and, in turn, interest in an engineering career. Houston and Xu's (2016) examination of post-secondary remedial mathematics course taking found that students who were low-income and whose parents only had a high school level of education were more likely to be in remedial mathematics courses in college. Additionally, Theokas and Saaris' (2013) report, *Finding America's Missing AP and IB Students*, highlighted how low-income students are three times less likely to be enrolled in AP courses than their middle and high-income peers. Studies overwhelmingly emphasize the importance of AP mathematics and science courses on students' pursuit of a STEM career (Maltese & Tai, 2011; Sadler, Sonnert, Tai, & Klopfenstein, 2010; Wai, Lubinski, Benbow, & Steiger, 2010). Likewise, a study examining the mathematics course taking sequence of high school students, using a nationally representative dataset, found that students whose parents socioeconomic status was in the bottom quartile were less likely to have taken precalculus or calculus courses in high school (Champion & Mesa, 2016). In the sample of first-generation college students in their first year in college, I found that when examining the high school mathematics courses taken, 52% indicated having taken an AP or

International Baccalaureate (IB) mathematics course, 26% indicated taking a mathematics honors or another advanced mathematics course. Perhaps through these formal experiences, first-generation college students were able to perform their competency in mathematics and, through this performance, be recognized by others and themselves as math type of people. Participation in some type of advanced mathematics course, as was the case for 78% of our sample of first-generation college students, is a form of entry into a community of practice where lived experiences reify one's identity (Wenger, 1998), are cites where students obtain recognition as mathematics type of people (Gee, 2000), and develop a disciplinary identity that facilitates other disciplinary identities.

Students choosing to go into engineering, in some way, identify themselves as individuals that can do engineering and be engineers based on exposure to course material and experiences both in and out of the classroom setting. In prior work, high school students discussed anyone as being capable of assuming a mathematics or science identity if they worked hard or were interested enough. These same students tended to put more limitations on who can be a physics person or an engineer (Verdín, Godwin, & Ross, 2018). Specifically, high school students described those who can be a physics person and an engineer as an identity held by elite (i.e., saw the world "differently" than most people) or "super smart" people (Verdín, Godwin, & Ross, 2018, p. 41). However, not all students take physics courses, and in some cases, students may be deterred from taking physics altogether. For example, one participant from prior work, Casey, in a high school with particularly low female enrollment in physics class noted that physics was not highly emphasized, she stated, "I feel like it [physics] should be pushed more. Like they pushed, ah, Earth and Space really hard …" (Verdín, Godwin, & Ross, 2018, p. 42). Casey, became involved in Project Lead the Way through her mom's encouragement and her school's explicit opposition, in an interview she stated, "my mom was like, yeah they didn't want to put any of the girls in engineering because they were like, oh this just for the boys, so they presented the girls with Spanish and the boys with engineering" (unpublished Interview transcript from Verdín, Godwin, & Ross (2018) publication). While there are certainly efforts to push for women's participation in engineering, in the case of Casey, ways of systematically excluding women from experiences that provide access to author a physics and subsequently an engineering identity.

Students develop disciplinary identities through the backdrop of societal and institutional structures; in turn, they facilitate or constrain the kinds of identities available to them (Herbel-

Eisenmann, Choppin, Wagner, & Pimm, 2012). The model structure was consistent for both women and men (validated through measurement invariance). While I modeled a pattern of relationships that holds for both women and men who are the first in their families to attend college, for women, they face a constant negotiation of receiving and being denied recognition as mathematics, physics or engineering type of people (Benedict et al., 2018; Carlone & Johnson, 2007; Johnson et al., 2011). I can conclude that perhaps the pathway towards identifying as a math, physics, and engineering type of person is not linear for both women and men. Instead, women face additional hurdles (i.e., environmental constraints) towards receiving and internalizing the recognition required for identity development that men do not face; however, when women surpass the environmental constraints acting on them, they do, develop an identity. In my next study, in Chapter 5, I present a case of a participant whose journey of seeing herself as a mathematics, physics, and engineering type of person was a hard-won standpoint. Yet seeing herself as a mathematics type of person was instrumental in her pathway towards seeing herself as a physics type of person (discussion of this participants' trajectory will be presented in Chapter 5). In sum, the relationships in this model confirm that first-generation college students have had some sort of identity shaping experience in the context of mathematics and physics and the exposure to this content knowledge supported the formation of an engineering identity.

4.10.3 H3. Personal agency will support mathematics, physics, and engineering identity

My results demonstrate that first-generation college students' agentic capabilities supports their formation of a mathematics identity ($\beta = .406$, $p < .001$), physics identity ($\beta = .198$, $p < .01$), and engineering identity ($\beta = .316$, $p < .001$). First-generation college students' daily interaction with individuals or situations (e.g., institution, classes, family, neighborhood, work, etc.) either constrain or enable them to take on particular identities and enact their agency. Identities are created, recreated, and sustained through participation in activities and reflexivity (Brickhouse & Potter, 2001; Roth et al., 2004). Coté and Levine (2002) also affirm that "identity is a function of both external (social) and internal (agentic) factors," both perspectives are necessary for a holistic understanding of the complexities of human self-definition (i.e., identity; p. 9). Agentic actions allow individuals to explore, maneuver, and impact their environment for the achievement of a goal or set of goals (Bandura, 2001). Students' personal agency is achieved through the capabilities of forethoughtful perspectives, intentional actions, self-reactive a form of self-regulation, and reflectivity (Bandura, 2006). The result of an agentic behavior is a change or remake of one's environment (Bandura, 2001). While those who are skeptical of their abilities to exercise personal agency undermine their efforts in challenging situations.

Understanding the development of a disciplinary role identity through an agential point of view implies considering how first-generation college students construct their identity "rather than act in accordance with an imposed identity" (Shanahan, 2009, p. 45). Sewell (1999), drawing from the work of Giddens (1976), acknowledged that structures enable human agency, and, in this context, the structured knowledge enabled the authoring of a mathematics, physics, and engineering identity. The relationship between agency and disciplinary role identities constitutes an intentional action on the part of the agent who has put into practice their necessarily structured knowledge (i.e., the knowledge gained within a disciplinary context) of what it means to be a mathematics, physics, or engineering type of person.

Brickhouse (2001) affirmed that while identity focuses on the individual, it also accounts for the importance of both individual agency as well as "societal structures that constrain individual possibilities" (p. 286). Students' disciplinary identities are as much an outcome of their intentional, goal-directed actions (i.e., personal agency) as it is of the societal structures. People in general, but students specifically, are more likely to take action or act upon their environments based on their beliefs (Bandura, 1986, 1997). Students' behaviors are "motivated and regulated by internal standards and self-evaluative reactions to their own actions" (Bandura, 1986, p. 20). This quote suggests that first-generation college students, have actively evaluated themselves in relation to their experiences with STEM activities or coursework and have taken on the identities of STEM type of people. Eisenhart and Finkel (1998) affirmed the kinds of identities afforded to students through school activities could help them "change, grow, and learn" based on images of the identities represented in the activities (p. 240). They posit, "if the activities of school science represent identities that are interesting, believable, and possible for students to achieve (given existing demands and expectations)," then students are more likely to pursue these identities (Eisenhart & Finkel, 1998, p. 240). This point is evident in Boaler and Greeno's (2000) comparison of six high school calculus classes with disparate pedagogical practices; one particular practice positioned students as active agents in the classroom, contributing to the shared understanding of mathematical concepts. Thus, I contend that first-generation college students' disciplinary identities are as much an outcome of their actions, through their personal agency, and evaluation of themselves as capable STEM learners as it is of the social structures. There is an interaction between agency and identity in that enacting agency involves a reflective practice, and it requires that the student continually negotiate their identities-in-practice as they move towards seeing themselves as math, physics, and engineering type of people and reaching their goals through engineering.

Students' reactions and choices made in response to their imposed environment constitute their selected environment. For example, Sandra, a first-generation college student from prior work by Verdín and Godwin (2018a), as she navigated through the imposed environment of gender discrimination in a mechanical engineering course stated, I have had friends … they have told me in the past that it is hard for them to listen to a woman because … 'it's like … in my mind it's still set that I know what I'm doing because I'm the guy …'" (p. 281). Sandra, enacting her agency by pushing against the imposed environment, reflected on her constructed environment and how she is positioned in that environment stating, "I can understand where they are coming from 'cause maybe that's the culture in his family and where he's from" (Verdín & Godwin, 2018a, p. 281). In other words, Sandra's reflection of her environment did not position women as less knowledgeable than men; thus, her male friend's constraining beliefs were his issues alone and not a reflection of her as an engineer.

First-generation college students enter engineering as capable agentic individuals; part of what it means to regard people as agentic "is to conceive of them as *empowered* by access to resources of one kind or another" (Sewell, 1992, p. 10; emphasis in original). The work of Smith and Lucena (2016a; 2016b; 2015) examined the accumulated bodies of knowledge from home and work practices that first-generation college students hold as a result of coming from low-income communities. Smith and Lucena's work, pushing the narrative of first-generation college students beyond the deficit model, positioned students as holding valuable engineering knowledge obtained through interactions with working-class families and community members. However, the burden of educating others on how to uphold an inclusive environment should not be placed on marginalized students. Rather educators, I believe, should be focused on empowering students' agentic capabilities.

4.10.4 H4. Personal agency will support first-generation college students' disposition to make a difference in their world through engineering (i.e., engineering agency beliefs), and their engineering agency beliefs will support the formation of an engineering identity

First-generation college students, viewed as agentic actors, are capable of acting and changing their environment or world around them. The latent construct of engineering agency beliefs captures first-generation college students' desire to make a difference in the world and their community through engineering. Students' dispositional beliefs of making a difference in the world using engineering as the tool or resource were supported, in large part, by the exercise of their personal agency ($\beta = .517$, $p < .001$). Seeing oneself as a capable physics and mathematics type of person modestly supports first-generation college students' desires to make a difference, ($\beta = .166$, $p < .05$ and $\beta = .106$, $p < .05$ respectively). Lastly, first-generation college students' desires to make a difference in the world and their community using engineering knowledge as a tool supported the formation of an engineering identity ($\beta = .285$, $p < .01$). Critical engineering agency acknowledges that first-generation college students are critically reflective citizens who have the capacity to "address and act upon questions of personal and social importance," and are capable of "acting upon the world in purposeful ways, with the aim of creating, impacting, and/or transforming themselves and/or the condition of their lives" (Turner, 2003, p. 18; Turner & Varley, 2007). Enacting agency is a practice on the part of the agent (i.e., first-generation college students) to make intentional choice and act on these intentions. My model demonstrates that first-generation college students' outcome of enacting their personal agency is an active goal of changing or remaking their environment and world around them (i.e., enacting their engineering agency). I emphasize that the students sampled in this study are in their first year in their engineering program, and they are entering engineering programs, having established a desire to use engineering in socially meaningful ways. These students believe that through the enactment of their personal agency they can make meaningful social change.

Engineering agency beliefs simultaneously incorporates expressing identity (through actions) that are relevant to one's world and critical (questioning) of the social and cultural structures in place. I illustrate this point by revisiting Sam's narrative. Although Sam's family struggled financially (an environmental constraint), she held a strong desire to enact her engineering agency towards making a difference in the world. Her personal agency drove her to pursue a college degree, and when probed on how she became interested specifically in pursuing an engineering degree, stated,

> As I grew up, I saw all those [technological] changes. I just saw how that improved people’s lives … I really was interested in engineering because it always involved some type of innovation. It involved all types of areas in people’s lives, from construction to building roads to computers, even in medicine. Engineering takes part of everything. I really wanted to make an impact on an aspect of someone's life.

Through forward-directed planning and intentional goal setting, Sam positioned herself in an engineering program where she could enact her disposition towards making a difference not only in her life but also in the lives of those around her through engineering. Through this positioning, Sam is not only enacting her personal agency for the achievement of a goal (i.e., using engineering to make people’s lives easier) but through her agency, she is establishing herself as someone that can use engineering, thus (re)forming her identity in practice. In general, the first-generation college students sampled in this study through intentional action, forward-directed planning (i.e., agentic capabilities) are situating themselves in an environment where they can use engineering as a tool to pursue personally and socially meaningful goals.

4.11 Conclusion

First-generation college students are entering their engineering programs with the capacity to be intentional, reflective agents. This capacity supported the formation of all three disciplinary role identities and their beliefs of making a difference in the world through engineering (i.e., enacting their critical engineering agency). Educators need to view first-generation college students as agentic individuals capable of (re)shaping the events that affect their lives. While I am not dismissing the unequal educational disparities between first-generation college students and their counterparts, I am calling for a shift in how educators engage with this group of students. The messages educators transmit to students in their first weeks as engineering students shape how they see themselves in relation to the campus environment and their perceived fit within the engineering program. Students’ capacity to be reflective and forethoughtful are important for progressing through their respective engineering programs as agentic actions involve “exploring, manipulating and influencing the environment” (Bandura, 1999c, p. 4). Likewise, agentic actions allow first-generation college students to shape who they see themselves as, i.e., engineering type of people, and the personal and social goals they wish to enact in the future through engineering. This study informs educators on the ways first-generation college students want to use their engineering knowledge, that is, in personally and socially meaningful ways. Situating first-generation college students as active agents of change moves the national discourse of educating engineers away from national economic vitality towards a student-centered benefit. Positioning first-generation college students as engineering learners ready to create positive change in the world or their community through engineering can solidify their engineering identity-in-practice as they progress through their programs. Providing first-generation college students with opportunities to enact their engineering agency beliefs through service-learning design programs, for example, can transform their engineering agency beliefs into more tangible actions.

5. STUDY 3 “I DON’T FIT THE NUMBERS”: A NARRATIVE ANALYSIS OF HOW ONE LATINA, FIRST-GENERATION COLLEGE STUDENT AUTHORS HER IDENTITY AS AN ENGINEER

5.1 Introduction

Identities are dynamic, malleable, and are influenced by situations and interactions (i.e., sociohistorical struggles, environmental factors), yet students have the agency to adopt identities they see congruent with who they want to become. In this study, I used the domain-specific identity approach; this approach situates identity development as an interplay between disciplinary interest, beliefs about performing well and understanding content material, and being recognized by others as a STEM type of person and subsequently accepting and internalizing that recognition (Carlone & Johnson, 2007; Godwin, Potvin, Hazari, & Lock, 2016; Hazari, Sonnert, Sadler, & Shanahan, 2010; Verdín, Godwin, & Ross, 2018). Authoring a disciplinary role identity develops through activities and social practice that takes a great deal of negotiation and agentic capabilities (Holland et al., 1998).

Agency is students’ “beliefs about their capabilities to exercise control over events that affect their lives” (Bandura, 1989, p. 1175). The capacity individuals hold to make changes in their lives and the world around them subsequently fosters identity development. Becoming the type of person one envisions for herself is an agentic act requiring intentional choices and reflectivity on the outcome of these choices (Bandura, 2008b). Agentic actions allow students to explore, maneuver, and impact their environment for the achievement of a goal or set of goals (Bandura, 2001). The result of an agentic behavior is a change or remake of one’s environment and actions produced for a given purpose are the core feature of a students’ agency (Bandura, 2001; Giddens, 1984; Holland, Lachicotte, Skinner, & Cain, 1998).

In addition, society shapes the self, and the self, in turn, shapes society (Holland et al., 1998); this recursive process influences the self in various stages of a student’s life course. Students have the capacity to shape society or their world around them by exercising their personal agency. Personal agency is the capability a person holds to make choices and to act on those choices in ways that make a difference (Bandura, 1999a). Enacting one’s agency means “exerting some degree of control over the social relations in which one is enmeshed, which in turn implies the ability to transform those social relations” (Sewell, 1992, p. 20). A student displays agency when constructing their identity; however, this construction process occurs within contextual constraints (Schwartz, Luyckx, & Vignoles, 2011). These contextual constraints can be conceptualized as three types of environmental factors, that is, environments that are *imposed*, *selected*, or *constructed* (Bandura, 2001). An imposed environment may include daily situations, or circumstances a student interacts with (e.g., communities of practice, school settings, microaggressions, racism, etc.). Imposed environments may not allow students the capability to make changes in their lives. Likewise, imposed environments are often created by the messages that circulate about who gets to participate in a certain field or who is recognized as a legitimate member of a community of practice. However, students do have the ability to interpret and react to their imposed environment. Even within imposed environments, students can also select their environment based on their reactions, interpretations, and resistance. Lastly, a constructed environment requires students to actively engage in and with their surroundings, through the process of engagement, students can acquire new knowledge, dispositions, and behaviors. I framed environmental factors as imposed, selected, and constructed because they underscore the ability for students to enact their agency as well as emphasized when agency is being suppressed. Each form of environment will require different levels of agency and a student can shape their environment through the enactment of their agency. The environments students navigate through have identity shaping consequences because identities are dynamically constructed through experiences (Oyserman et al., 2012).

Bandura maintained that through an agentic perspective, individuals could imagine futures that propel action in the present moment, "modify alternative courses of action to secure valued outcomes, and override environmental influences" (Bandura, 2008a, p. 87). This study situates first-generation college students through an agentic perspective. Foregrounding agency as the approach to understanding first-generation college students acknowledges that these students are active contributors to their life course by selecting, influencing and constructing their environment.

5.2 Intersecting Identities

At any given time, an individual embodies multiple and intersecting roles, social, and personal identities. Additionally, the context or situation in which an individual is situated, at any point in time, shapes which identities are most important at that moment (i.e., the saliency of an identity; (Burke & Stets, 2009). Stryker (2002) noted that as society becomes more complex, the groups, organizations, and roles available to an individual also increase. These multiple identities in the postmodern era, Burke and Stets (2009) argued, have less in common with one another or have less shared meanings, which means verifying these multiple and disparate identities calls for negotiation of multiple and disparate meanings across settings. Conversely, a common or shared meaning would support identity verification or that "verifying one of the identities will help verify the other and the two identities can coordinate their outputs to verify both" (Burke & Stets, 2009, p. 135).

An identity that becomes salient to the participant that I focus on in this study is that of a nontraditional student. Students considered nontraditional students are at minimum 25 years old, attend school part-time, work full-time, have children, or waited several years to enter college after high school, among other factors (MacDonald, 2018). Burke and Stets (2009) affirmed that when multiple identities are "called up" or activated in different situations, this activation of identity may conflict with the activation of the other identity as the behaviors and actions congruent with one may be conflicting the other (p. 140).

Intersectionality also becomes an important tool for which to understand first-generation college students as it "acknowledges an individual's multiple social identities" (i.e., first-generation college student, Latina, nontraditional student) and creates a complete representation of the "whole person" and their struggles (Wijeyesinghe & Jones, 2014, p. 11). Intersectionality is grounded in feminist theories of power and difference and emerged in the 1980s as a way of analyzing women's sources of oppression. Specifically, Crenshaw (1991) fashioned the term intersectionality to express "the various ways race and gender interacted to shape the multiple dimensions of black women's employment experiences" (p. 1244). Thus, intersectionality aids in examining "the interaction between gender, race, [class], and other categories of difference in individual lives, social practices, institutional arrangements, and cultural ideologies and the outcomes of these interactions in terms of power" (Davis, 2008, p. 68).

Intersectionality in higher education encourages researchers to consider the multiple facets of students' identity, "notwithstanding the salience individuals attach to them personally," as well as highlights how individuals have experienced marginalization and inequalities based in multiple and compounding non-dominant identities (Wijeyesinghe & Jones, 2014, p. 12). This framework offers a way of exposing how the different categories of oppression are interconnected and interdependent (Bastia, 2014) and is appropriate for this population because similar to other women of color, a Latina identity incorporates both ethnic and gender identities (Crenshaw, 1991; Jaramillo, 2010). Similarly, being of low socioeconomic status and a first-generation college student is often systematically tied to being Latina. Furthermore, acknowledging that one identity cannot be isolated from the other, or that some students will identify with particular identities, gives a holistic representation of my participants and how their experiences in engineering are shaped.

I have chosen to subset the first-generation college student population to only Latinas because I can more precisely speak on behalf of *one* portion of the population rather than speaking to the experiences of all. It is also important to emphasize that I do not believe there is a monolithic Latino/a culture, however, what is true is that "many Latino/a are steeped in cultures that are significantly different from both the culture of their public schools and the culture taught by those schools" (Sampson, 2003, p. 5). Dasgupta (2011) illustrated the importance of belonging,

> Because the need to belong is particularly strong under adversity or stress, it is likely to play an important role in the lives of individuals who belong to historically disadvantaged groups and find themselves in adverse situations where their group is numerically scarce and their abilities cast in doubt (p. 232)

Even though there are differences within the Latino/a culture, struggling to belong remains prevalent as the Latino/a community continues to be underrepresented in engineering education and academia. Therefore, it is important to examine the interplay of the first-generation college status, gender, and race/ethnicity, which will allow for a holistic representation of women at the intersections of these identities. Counterstories can help understand inequities of the Latino/a educational condition and can help point to the biases of the majoritarian educational system Latinas navigate and allows for the exploration of multiple identities (Yosso, 2006, p. 4). Counterstories have roots in critical race theory, it has been used to "raise critical consciousness about social and racial injustice," and "challenge majoritarian stories that omit and distort the histories and realities of oppressed communities" (Yosso, 2006, p. 4).

5.3 Becoming an Engineer

Learning is an ongoing process of participating in a community of practice, and becoming a member involves taking on roles, behaviors, and attitudes that are defined and shared within the community (Allie et al., 2009; Burke & Stets, 2000). Identities develop as an outcome of participating within a community of practice (Holland et al., 1998). However, if learning is an ongoing process, as Allie and colleagues (2009) argued,

> it is not possible to view learning as participation without explicit consideration of the ... background of the students, the communities that students already belong to or have belonged to in the recent past, and the workplace community in which the successful student will need to function (p. 360).

Allie and colleagues (2009) hypothesized that a lack of integration among existing identities and a new engineering identity can lead to poor academic performance or can lead to opting out of a career in engineering. In contrast, educational success involves integration into the culture of engineering, an integration process that is centered around identifying as someone that can do or become an engineer (Foor et al., 2007). Jorgenson (2002), studied the types of gender identities women in engineering claimed and found that women often positioned themselves as non-feminine and were reluctant to position their experiences as women in predominantly male fields. Rather, some women in her study were eager to separate themselves from "ordinary" women, believe engineering is a "gender-neutral territory," and were in opposition to women in engineering organizations. These accounts of dismissing or rejecting their female identity were "strategies widely observed among female scientists and engineers to disqualify their femininity by muting their visibility as women" (Jorgenson, 2002, p. 370). I have seen this trend in my research, as well.

In my prior qualitative study of Latina, first-generation college students, one participant, Sandra, spoke about having to shift her behavior and "become more aggressive when talking to her male peers due to feelings of exclusion" (Verdín & Godwin, 2017a, p. 13). Sandra went on to identify less like a woman and more as an engineer to assimilate into the engineering culture and be recognized as a legitimate participant (Verdín & Godwin, 2017a). For Sandra, to be positioned as an engineer required that she conform to the perceived masculine social norms of engineering. She described needing to look like an engineer, talk like an engineer, and act like an engineer to fit into her environment. The act of downplaying femininity or gender identity for many women engineers is consistent with other studies related to gender and engineering identity (Du, 2006; Phipps, 2002). Conversely, in my prior study of Latina, first-generation college students, another participant, Carmen, found herself at times to be the only Latina in her electrical engineering courses and felt the need to disprove stereotypes about her performance and prove she belonged in the field (Verdín & Godwin, 2017a). Carmen's attention shift, compared to Sandra's, was subtle but important; that is, Carmen focused on being Latina (an interplay between ethnic and gender identity) and disproving the stereotypes that are not only attached to being female but also being of an ethnic minority group. Her approach embraced her multiple identities to shift the narrative about her group. These studies highlight negotiations women have to take to identify as engineers.

Tonso (2007) posited that "identities serve as focal points for learning to belong in communities of practice" (p. 27) and that, once inside an engineering community of practice, students begin to formulate their identities. Often, students are implicitly expected to choose between one aspect of who they are versus what it means to be an engineer. Matusovich and colleagues (2010) affirmed this notion by drawing awareness to the disconnect between students' personal identities ("aspect of ourselves that make us unique" (p. 290)) and engineering identity and emphasize the need for these types of identities to be associated throughout the students engineering pathway. This disconnect in personal identity and being an engineer was seen in a study, focused on characteristics that enabled students to belong in engineering, where a participant, Anika, noted that her artistic skills (personal identity) was a trait that made her unlike an engineer (Benedict, Verdín, Godwin, & Milton, 2017). Participation in an engineering community of practice not only supports the development of students' identity, but it also means that students are not entirely free to develop any type of engineering identity, rather they are guided by "larger and more pervasive meanings of [engineering] identity derived from sociohistorical legacies of [engineering]; and historical and political meanings of being" an underrepresented student (i.e., Latina, first-generation college student; Carlone & Johnson, 2007, p. 1192). It is important to know who students are expected to be; that is, enculturation into an engineering community of practice often requires that educators understand how students associate with, withdraw from, or negotiate the cultural norms of the community and their identities. Therefore, in this study, I use the narrative of *one* Latina who occupies multiple identities in order to understand how her experiences shaped the way she authored an engineering identity.

5.4 Research Questions

RQ1. What are the experiences that shaped how a Latina, first-generation college student authored her engineering identity?

RQ2. What experiences prompted her to negotiate her multiple identities?

5.5 Rationale for Using Qualitative Methodology: Theoretical Foundations

A qualitative research approach was selected for this study, as it is the ideal way to uncover real-life events and experiences of people. Qualitative research is a "form of social inquiry that focuses on the way people interpret and make sense of their experiences and the world in which they live" (Holloway, 1997, p. 2). It involves the collection of various forms of empirical information, "case study, personal experiences, life story, interview, observational, ... and visual text" to name a few with the aim to describe moments and meanings in people's lives (Denzin & Lincoln, 1994, p. 2). This paradigm is ideal for my study as I seek to understand how a marginalized member of the engineering culture, a Latina, first-generation college student, uses her agency to author her identities as an engineer and make a change in her world and/or community (i.e., enact critical engineering agency).

This study is a narrative inquiry to tell the story of one participant, Kitatoi. Using narrative inquiry allowed me to represent a complete story of my participant's lived experiences and how these experiences helped in authoring an identity as an engineer. Since disciplinary role identities develop through experience, narrative inquiry offered me a way of exploring how identities where shaped and reshaped through participation. Narrative is a way of presenting human experience (Connelly & Clandinin, 1990; Kim, 2016; Polkinghorne, 1988). Connelly and Clandinin (1990) when describing narrative inquiry stated, "people by nature lead storied lives and tell stories of those lives" and researchers who engage in narrative inquiry "describe such lives, collect and tell stories of them, and write narratives of experience" (p. 2). Kim (2016) clarified that stories are a "'full' description of lived experience[s]," while narratives are "'partial' descriptions of lived experiences" (p. 9). Stories are organized narrative events, thus stories rely on narratives, they are intertwined (Kim, 2016). Narrative educational research positions the researcher and participant as a storyteller, as characters, and allows for construction and reconstruction of personal and social stories. Experience is relegated to text, text forms represent the experience under study (Clandinin & Connelly, 1994). Clandinin (2006b), argued against studying experience as only contained in text, by linking to ways of thinking about experience to research methodology.

Experience is the cornerstone of narrative inquiry. Clandinin and Connelly (1990, 2000, 2006) and the Deweyan view of experience is fundamental to understanding narrative inquiry. Dewey's theory of experience stated that "experience … influences the formation of attitudes of desire and purpose… and every experience lives on in further experiences" (Dewey, 1938, p. 35).

Interaction is a component of the theory of experience. We live our lives through interaction with the world around us, "life goes on in an environment; not merely in it but because of it, through interaction with it" (Dewey, 1934, p. 15).

In framing experience, continuity and interaction are central to Dewey's theory of experience (Clandinin & Connelly, 1994). That is, experiences do not occur by happenstance; rather, "they are historical and temporally directional according to the intentionality of the [person] undergoing experience" (Clandinin & Connelly, 1994, p. 417). Clandinin and Connelly (2000) asserted that people should be understood as individuals, but they cannot *only* be understood as individuals as "they are always in relation, always in a social context" (p. 2). Thus, using Dewey's theory of experience as a conceptual backdrop, Clandinin and Connelly (1990, 2000, 2006) framed narrative inquiry in a three-dimensional space that uses Dewey's criteria of interaction and continuity (Clandinin, 2006b). The three-dimensional space metaphor is used to help narrative inquirers navigate the space of inquirer travel in "directions"—*inward*, *outward*, *backward*, and *forward,* and *situated within place* (Clandinin & Connelly, 2000, p. 50). Polkinghorne (1988) also affirmed the temporal forms in narrative inquiry, noting that experiences are drawn from the continual flow of successive events. In Table 5.1, I have outlined specifics about these temporal dimensions of past, present, and future (continuity), the two forms of interactions (i.e., personal and social), and what it means to be placed within a situation. The three-dimensional space metaphor is used to help narrative inquirers navigate the space of inquiry. To embark on a journey of narrative inquiry, "there needs to be a simultaneous explanation of all three commonplaces"—temporality (continuity), sociality (interaction), and place (situation; Clandinin, Pushor, & Orr, 2007, p. 21).

Table 5.1. Three-dimensional narrative inquiry space

Continuity (temporality)			**Interaction**		**Situation**
Past	Present	Future	Personal	Social	Place
Looking *backward* to remembered experiences, feelings, and stories from earlier times	Looking at current experiences, feelings, and stories relating to actions of an event	Looking *forward* to implied and possible experiences and plot lines	Looking *inward* to internal conditions, feelings, hopes, aesthetic, reactions, moral dispositions	Looking *outward* to existential conditions in the environment with other people and their interactions, purposes, assumptions, and points of view	Looking at context, time, and place *situated* in a physical landscape or setting within topological and spatial boundaries with characters' intensions, purposes, and different points of view

Note. context adapted from Clandinin & Connelly (2000); Clandinin & Huber (2010); Clandinin, Pushor, & Orr (2007)

A narrative inquirer should understand that they are not objective participants in the study of experience; instead, they are in a relationship with the participant and both the researcher and the participant are learning and are changing through the encounter. Turning from the use of numbers towards words as data allows the researcher to preserve nuances of the experience, relationship between the researcher and participant, and the overall essence of examining human experience. Using narrative inquiry in this study provides depth to the results found in Study 2. For example, the participants in Study 2 were all in their first-year in college, none were transfer students; therefore, their disciplinary role identities were shaped through the high school, middle school and elementary experiences they may have had. Many of the first-generation college students in Study 2 followed a traditional linear path, 39% of the sample, took advanced mathematics courses (i.e., Calculus AB) and 85% of these students took some type of physics course in high school. Albeit the linear path they followed was specific to a path that a student who is the first in their families to attend college could take. Therefore, focusing on a student's narrative with a non-linear trajectory adds a rich account of how disciplinary role identities are developed. Lastly, Pinnegar and Daynes (2007) stated that a researcher should consider when conducting narrative inquiry is moving away from one way of knowing the world to and "understanding that there are multiple ways of knowing and understanding human experience" (p. 25). This notion that there are multiple ways of knowing and multiple understandings comes into fruition in Kitatoi's lived experiences.

5.6 Recruiting Participants

Two different methods were used to recruit participants 1) email list from CAREER survey and 2) my social network.

First, I attempted to recruit participants from the list of emails provided in the CAREER: Study of Students' Underlying Attitudes and Beliefs in Engineering (NSF 1554057) survey. I recruited women who identified as being "Latino/a or Hispanic" and who indicated both of their parents had "less than a high school diploma," "high school diploma/GED," or "some college or associate/trade degree" (i.e., first-generation college students). Within this dataset, I was also constrained to only students who indicated they would be interested in follow up questions and provided contact information. I was limited to sixteen potential participants after filtering the dataset to students who met the demographic classifications and provided contact information. A recruitment email was sent to all sixteen potential participants in July 2018 (see Appendix G for email invitation); however, a few emails failed to send, and none of the students indicated interest or disinterest in participating in the study. I concluded that summer was not the best time to contact participants; therefore, a second email was sent in October 2018; only one participant indicated she was interested in being part of my study. Due to the lack of response from my shortlist of potential participants, I decided to leverage my social network.

The second method for recruitment that I used was leveraging my social network. As an undergraduate student, I was part of a California statewide initiative that supported underrepresented students in STEM fields, the Mathematics Engineering Science Achievement (MESA) Engineering Program. The director of the MESA Engineering Program at my alma mater sent my recruitment email to her MESA students and a few of her colleagues in other MESA Engineering Programs. By utilizing my social network, I was able to recruit two additional participants and through family connections, I was able to recruit a fourth participant.

While my initial goal was to have a bounded case study of students who were in their first-year in college and identified as Latinas in engineering, I was met with the reality that this bounded group was few in numbers. Reports continue to emphasize that most first-generation college students have passed through community college and are older than the 'traditional' undergraduate student body (National Academies of Sciences Engineering and Medicine, 2016; Whitley et al., 2018). Therefore, I welcomed the fact that my participants were in diverse educational trajectories; I highlight the diverse educational trajectories of my participants in Table 5.2. After conducting a series of interviews with the four participants that agreed to be part of my study, I identified a single participant whose narrative provided richness and depth that was missing from Study 2. Therefore, I decided to focus on one case to do justice to the journey of personal growth that one participant, Kitatoi, has undergone through the six years she spent at community college and the experiences she has had at Research State University. When I started to review the transcripts of my participants, Kitatoi's words, "I'm the student that doesn't fit in … I don't fit the numbers …" resonated and held true in comparison to my other three participants and the students in Study 2 who were first-semester, first-year college students. Kitatoi's journey offers engineering educators an understanding of an educational pathway into engineering that is different from the traditional age college student. Additionally, Kim (2016) contended that for narrative inquiry, "the adequacy of the sample is not determined solely by the number of informants, but by the appropriateness of the data" (p.161). Thus, I decided Study 3 would focus exclusively on the experiences that lead Kitatoi to see herself as someone who can do engineering.

Table 5.2. Current year in school when first interview was conducted

Participant Pseudonym	Educational Standing During First Interview	Interview Timeline
Sam	First-year in State Teaching University in Central California	Interview 1- October 2018 Interview 2- March 2019 Interview 3- September 2019
Jane	Attended Aeronautical University in Arizona for four semesters and was currently enrolled in her local community college	Interview 1- October 2018 Interview 2- March 2019 Interview 3- August 2019
Lupe	Fifth year in State Teaching University in Southern California	Interview 1- October 2018 Interview 2- March 2019 Interview 3- September 2019
Kitatoi	Attended community college for six years as a part-time student and is currently in her first quarter at Research State University in Southern California	Interview 1- March 2019 Interview 2- August 2019 Interview 3- December 2019 *I also had several email exchanges with this participant to clarify statements that were made in prior interviews.

Note. All pseudonyms were selected by participants

5.7 Data Collection

I conducted three interviews that ranged from 60-90 minutes each at different time points using an online video/audio software called Zoom. The interviews were audio-recorded and later transcribed using a professional transcription service. At times, I contacted participants via email to obtain minor clarifications.

I conducted interviews with all four participants and their interviews were structured the same. The goal of the first interview was to understand my participants' background experiences, the pathway that lead them to engineering, and to talk about any early engineering-related experiences they may have had. In the first interview, I focused on broad overarching questions, 1) Can you tell me about how you came to be where you are now, 2) Tell me about your pathway into engineering, and 3) Tell me about your experience as a first-year engineering student. For each set of questions, I had followed up questions in the event that participants needed more help telling their story. In the second interview, I started with the broad overarching question of "Tell me about how your experience has been this past semester/quarter." As well, in the second interview, I compiled a list of follow up questions, from interview one, for each participant to capture aspects of their story that I may have missed. In the third interview, I asked students to create a journey map, before our scheduled interview time, and indicate highs and lows (or positive and negative experiences) that have been significant to their experience as an engineering student. However, my participants were not able to create their journey maps prior to the interview; therefore, the interview was spent creating the journey map and learning more about the experiences that were high and low points. The interview protocols used for the three interviews can be found in Appendix H.

5.8 Method of Analyzing Narratives

Polkinghorne (1995) described two types of methods for narrative inquiry: 1) analysis of narratives and 2) narrative analysis. Analysis of narratives involves creating "descriptions of themes that hold across stories or taxonomies of types of stories," while narrative analysis describes "events and happenings and synthesize[s] or configure[s] them by means of a plot into a story or stories" (Polkinghorne, 1995, p. 12). The procedure I used in this study is narrative analysis, and this type of narrative inquiry moves from common elements of stories to stories with plots that are temporally organized (Polkinghorne, 1988, 1995). Using the method of narrative analysis allowed me to create a holistic journey of identity development for my selected participant, Kitatoi. Additionally, this method of analysis is especially beneficial to answer my research questions as it juxtaposes the findings from the structural equation model in Study 2. I could have selected the method of analysis of narratives to pragmatically identify categories to uncover the commonalities across my four participants. However, after collecting three rounds of interview data, I was drawn towards preserving the holistic lived experience of my participant Kitatoi. Therefore, I decided to present the case of one participant using the method of narrative analysis to configure her narrative as a "coherent whole" (Polkinghorne, 1995, p. 11), while maintaining "the metaphoric richness of [her]story" (Kim, 2016, p. 197).

Polkinghorne (1995) noted that in narrative analysis, the first step is to "arrange the data elements chronologically" (p. 18) because people often tell their stories in an inconsistent, non-linear fashion. Kim (2016) also noted that narrative analysis and the interpretation of narratives are an "act of finding *narrative meaning*" (p.190, emphasis in original). Narrative meaning described by Polkinghorne (1988) and Kim (2016) are mental processes that an individual undertakes to organize their experience into temporally meaningful chapters. Narrative meaning provides a framework for understanding past experiences and how an individual planned their future actions as a result of their experiences (Kim, 2016). Additionally, employing narrative analysis allowed me to underscore the unique and particular aspects of my participant's story. I configured the descriptions of events in temporal order by first examining the past, present, and future in a synthesized manner. I present the reader with a rich, nuanced meaning of human actions, allowing for an understanding of *why* and *how* events happened as they did and *why* and *how* the actions of a participant were selected (Kim, 2016). I used a constructed narrative approach with direct quotes (Kellam, Gerow, & Walther, 2015): this method uses the participant's words verbatim with connecting words, using square brackets (e.g., [ ]), to signal where I, the researcher, added in details or linker words to make the story smooth. I employed the method of narrative smoothing to focus the narrative, omit instances that are tangential to the overall story, and add transition points to clarify events to allow for an engaging and coherent story (Cruz & Kellam, 2017; Kim, 2016; Polkinghorne, 1995).

5.9 Assuring Quality and Validity in my Narrative Research Study

I look towards narrative research scholars' views of validity and the work of Walther, Sochacka, and Kellam (2013) for quality of interpretation. I used the quality management model proposed by Walther et al. (2013) as their model illustrates types of validity that are not linked to a particular research tradition or practice. Their typology for quality of the overall research process includes 1) theoretical validation, 2) procedural validation, 3) communicative validation, 4) pragmatic validation, and 5) process reliability. These five strategies were utilized in *making the data* and *handling the data*.

Theoretical validation is concerned with the fit between social reality and the theory produced (Walther et al., 2013). From prior work, students come to see themselves as engineers by being interested in the subject, being internally and externally recognized, and believing one can perform well in a STEM subject (Carlone & Johnson, 2007; Cribbs, Hazari, Sonnert, & Sadler, 2015; Godwin et al., 2016; Hazari et al., 2010). Additionally, findings from my dissertation Study 2 provided evidence that for first-generation college students, seeing oneself as a math person supports physics identity development. Both physics and mathematics identities support the claim of seeing oneself as the type of person that can do engineering. I was specifically interested in the experiences of those who identified as Latinas and who were the first in their families to attend college (i.e., purposive sampling); therefore, my participant, identified with these social identities. In the first interview (making the data) I had with my participant Kitatoi, I took care of ensuring she spoke about her mathematics and science coursework and how, if at all, they were relevant to her trajectory into an engineering field of study. Through this process, I ensured that the theory used to understand the phenomena of study was also present in the data collected. The interview naturalistically revealed that taking mathematics and physics courses were important in Kitatoi's trajectory. When constructing Kitatoi's narratives (handling the data), I was careful to capture her experience (i.e., social reality), as it was lived as opposed to how it fits the theory of engineering identity and agency. However, in my interpretation phase, I explained how Kitatoi's retold story could be understood by the theory of identity development.

Procedural Validation is concerned with incorporating features into the research design that improves the fit between reality and theory (Walther et al., 2013). I drew on the strategies outlined by Polkinghorne (2007) and Riessman (2008) as they specifically discussed narrative research. Polkinghorne (2007) described several validation strategies that can "convince readers of the likelihood that the support for the claim is strong enough that the claim can serve as a basis for understanding … human realm" (p. 476). Polkinghorne (2007) advised researchers to help participants elicit reflective meanings of their experiences since experiences are not simply a surface level phenomenon. In my three interviews with Kitatoi (making the data), I probed for deep reflections by asking, "how did this experience make you feel?" Throughout the three interviews, I empowered her to think of herself as the knowledge holder, and that she was granting me access to her lived experience. Additionally, Polkinghorne (2007) discussed mitigating social desirability and creating an atmosphere of comfort as well as gaining the confidence of the participant. Thus, I opened my interviews with a statement (making the data),

> I hope that you have the freedom and comfort to speak freely. There are no right or wrong answers here. I am not here to make judgments or criticize any comments you make. Some questions may seem repetitive, but I want to make sure that I am getting the full depth of the story.

I repeated sections of this statements through the interview when I asked probing questions or when I sought to elicit more depth of the experience from my participant. In making the data, Polkinghorne (2007) advised researchers to interview participants at least three times to gain confidence and trust with the interviewer; I scheduled three formal interviews with my participant, allowing at least four months in between interviews. Lastly, Polkinghorne and Riessman (2008) discussed the importance of grounding the interpretation of the storied text in theory and established literature in the researcher's respective field. In my interpretation of Kitatoi's journey into seeing herself as an engineer (handling the data), I drew from literature in the science, mathematics, and engineering education space along with literature from scholars concerned with educational issues of Mexican American youth.

Communicative validation is concerned with the knowledge that is co-constructed in the social context (Walther et al., 2013). Polkinghorne discussed this form of validation through the strategy of member-checking. After going through the process smoothing the narratives to create a temporal ordering of Kitatoi's experiences, I emailed a copy of the storied text to ensure that I correctly captured her lived experiences and gain the approval of the final product (handling the data). Riessman (2008) articulated how to establish narrative truths, which I think parallels communicative validation, by stating, "knowledge claims are valid if they accurately represent the relevant facts of the matter" (p. 188). In retelling the lived experience of Kitatoi (handling the data), I used her words verbatim to tell how she came to see herself as an engineer, only adding small smoothing points (using brackets) for cohesion.

Pragmatic validation is concerned with the "extent to which theories and concepts are compatible with the empirical reality" (Walther et al., 2013, p. 641). As previously stated, a growing body of work has corroborated the claim that developing a discipline-specific identity can be understood through interest, recognition, and performance/competence beliefs. The theory of identity development used in this study is corroborated through the experience of a non-traditional student with a unique educational trajectory. Kitatoi's story illustrates that the theory can be applied in a context outside of traditional-aged engineering students. In making the data, I did not lead my research participant to share experiences that fit my theory, rather the participant's experience naturalistically covered components of the theory.

Process reliability is concerned with making the "research process independent from random influence" (Walther et al., 2013, p. 641). In making the data, an interview protocol was approved by the Institutional Review Board (IRB); as external reviewers, they ensure the appropriateness of the interview protocol. I used a professional transcription service to transcribe my three audio interviews into text. The transcription service comes with a feature that simultaneously highlighted the words in the text as the interview recording was playing, thus allowing me to verify, with more precision, if my participants' words were captured accurately. Additionally, using this feature, I was able to correct the Spanish words and phrases my participant used that were not properly transcribed.

5.10 Findings

I present an in-depth description of the lived experience of Kitatoi, who provided a rich account of her life trajectory. Kitatoi spent six years as a part-time community college student before transferring to a bachelor's granting institution, and she is currently pursuing a bachelor's degree in mechanical engineering. Kitatoi shared experiences that were significant to her academic trajectory that spanned from primary education to her years in higher education. I've included Kitatoi's early experiences (i.e., during primary and secondary education) because they provide a rich understanding of why she felt disempowered as an adult in society and why her decision to enroll at community college was an agentic act. Following, I retell Kitatoi's narrative at community college, capturing experiences that both enabled and constrained her agency, and experiences that supported the development of her disciplinary role identities (i.e., mathematics, physics, and engineering).

5.11 Kitatoi's University Characteristics

Kitatoi, at the time of the interviews was attending a public university with a Carnegie Classification of R1 highest research activity. I use the pseudonym Research State University to refer to the institution she attended at the time of this study. Research State University is a Hispanic-Serving Institution, which is a classification by the U.S. Census Bureau as a degree-granting institution with a full-time undergraduate enrollment of 25% or more Latino/a students and the Latino/a population reporting income of at least 50% or below 150% of the poverty level (Flink, 2017; Li, 2007). Research State University has been continuously praised by *U.S. News & World Report* for being a beacon of social mobility to students in the surrounding geographic area, specifically enrolling a large portion of Pell Grant eligible students "than nearly every university in the country." Data from the National Center for Education Statistics in Fall 2018 indicated that 41% of the undergraduate population identified as Latino/a, 98% of students were enrolled as full-time students, and 95% of the undergraduate population were under 24 years old.

5.12 Kitatoi's Journey of Identity Development

Kitatoi shared the following story about her experiences that led her to study mechanical engineering at Research State University. I start Kitatoi's narrative exactly as she started her story and then smoothed in areas where she transitioned from one point in time to another. I began the interview asking Kitatoi an open-ended question, "Can you tell me how you came to where you are today?"

> I pretty much was aware that I didn't have any education, and I wasn't going to be able to get a job or support myself. I learned maybe 10 years ago that when my kids got to the age that they were going to need help with schoolwork like math, science, English, anything, I wasn't going to be able to help them because I had such a bad experience in high school. I felt really behind in high school. I didn't get anything out of high school, I just got the fuck out of there. I just had very little education and just very little knowledge about everything around me. I decided I don't want to be like that anymore. I want to know how things work. I wanted to be able to know history, know how to write a decent essay. I wanted to be able to know basic math. This was my goal, to be knowledgeable so I can help the kids with their homework.
>
> English is my second language. I had a teacher in second grade who was bilingual, and she helped me a lot. Then, I had her again in fourth grade y otra vez [and again] she help me a lot, then I went to fifth grade … I remember crying … I realized that

the teacher not only didn't speak Spanish, [but he also] told me that I had to deal with not having her [bilingual teacher] around to keep helping me. Ósea, que ya ni modo, que me aguanté [That is, there is no other way, you have to endure].

[In] middle school, I was just lost in understanding a lot of things, and teachers just sort of didn't pay attention to me 'til I messed up on something. Then, they realize it was a language thing y nomas me decían [and they would just tell me] well, "you gotta try harder" or some shit like that. Some me regañaban [would scold me] that I was falling behind or I'm at a lower level than I should be at or tell me that I needed to do something about it. A teacher told me that I needed to stop playing around with my friends so much and focus on the homework or readings. I never went out and had no friends in middle school.

I didn't really understand what I was reading … I didn't really know how to read that well in English … how to write in English ... I started really picking it [English] up, talking, reading and writing just very little maybe at an elementary level during middle school … but not where you're supposed to be at a high school level.

[In high school], I flunked English, freshman English, and I flunked math. I failed those classes, and I never told anybody because it was embarrassing. One of my English teachers, when she found out that English was my second language and that I was struggling, she did suggest [English Language Learner (ESL) classes], but I didn't really pay attention to it because I didn't want to be part of that little group of the ESL kids that just hung around in the back of the school. I just didn't want to be associated with them because of this stereotypical thing of "all the Mexicans hang out in the back of the school and nobody really pays attention to them. They're not going to get very far anyways," because that's what the vibe was in high school, and I didn't want to be a part of that. I had this idea that they were going to grow up and be housewives or pregnant at 16—the kids that were in those types of classes, the ESL classes. Everything was the lowest level. Lowest level English, lowest level math, lowest level any type of class. It was the easiest or maybe not easiest, but it was just the lowest level of anything. It was just like, if you’re part of this group and you’re going to this class, you’re not going to get really far in life. You’re not going to go to college. You’re pretty much just here to do high school, or else you’re going to get in trouble. I knew a lot of people that were in those groups that did just that. They dropped out of high school, they got pregnant at 16, they got these little jobs that high school dropouts get. I felt like if I associated myself with that, I was going to end up the same way … [but] … I wasn’t understanding the teachers, I wasn’t understanding the assignment. I wasn’t really understanding anything. I understood very little in order to pass high school, but I really don’t think I learned anything. I didn’t know how to write a basic essay or do basic arithmetic.

I didn’t have a good experience in high school, dropped out of college [community college] after a semester. I dropped out because I had no idea what I wanted to be when I grew up. I don’t remember being interested in anything, and since I didn’t do well in high school, I didn’t want to also not do well in college. I had zero self-esteem and no motivation to continue school. So, I got married and then got pregnant so that helped in my decision to drop out [of community college]. [I] just did that whole mother wife thing ‘til I learned that it wasn’t really for me.

I went back to school after 10 years of being out of school or dropping out of the first semester of college that I went to. I felt like that was a big moment for me, a big change. Just the fact that I’m deciding to go back to school, I felt like that was a really big change. I wanted to tackle the one thing that I was most intimidated by … I started with math … I felt like what better way.... I’m already turning my life around, I feel, with going back to school, what better way to actually do it than with tackling my biggest fear.

I decided to start with math because that was my biggest fear in high school, because I just didn’t get it. I didn’t understand it, and I didn’t want to put it off like, “Oh, I’ll start with these other classes, and then I’ll do math later.” I was more of like, “No, this is what I’m going to start with because otherwise ...” I don’t want to repeat the, “Oh, I’m scared of it. I’m scared of it … I’m going to put it off ‘til later, put it off ‘til later.” I didn’t want to do that. At the beginning, I felt really embarrassed because I was the oldest one. I was one of the oldest ones there, and I’m learning how to add, subtract, multiply, and divide. I learned how to divide at [age] 25 … the basic arithmetic stuff. It felt embarrassing a little, even humiliating. But, somehow, my mind was just changed like, “It doesn’t matter, I’m going to do this. It’s nobody else’s life. It’s my life.” I just learned how to put being embarrassed, ashamed aside, and I just started attending classes, doing the work. I had three kids at the time, so I had to balance going to school and having the kids, being a mom at the same time.

The first semester that I went, I took a math class, and I really struggled with it only because I had to learn to adjust to being a student then being a mom. I wanted to focus all of my time and all of my attention to my classes. I wasn’t really understanding my classes because they were actually very difficult. At the time, I thought they were very difficult. I would take an exam, and I would get a C, and I would take another exam and I would get another C. I would do all the homework, I would practice the problems, I would stay up late, I would wake up early just to practice more, and I really felt like I was understanding the professor when he taught. But, when I took a test, I would get a C. I would get really frustrated with myself like, “I’m really trying my best here,” and the best that I could do according to these tests is average. I started thinking maybe the saying is true. It’s not for everybody. It’s only a certain type of people that understand this concept. I can’t say that, “Oh, it’s because I didn’t study enough.” I was really studying my ass off. I was practicing, I was getting help. I was doing all that, and I still wasn’t ... I wasn’t getting the As on the exams, because if you get As that means you’re really understanding everything. That means you’re good to go. I actually passed that semester of pre-algebra with a C, and I just felt really disappointed because I thought I don’t have any more to give. I don’t have any more energy to give. I can’t practice more than I’m already practicing because I’m already practicing as much as I could possibly practice. I’m reading these books and out of my best effort, all

I get is a C, in average. I'm not studying at an average level. I'm studying my ass off here, and I'm barely doing average. I started to give up because I felt like, "No, I guess math is just not for me." I was just talking to my husband at the time, and was getting encouraged to just keep going, to just give it another shot, to just learn to manage my time so that I was able to do everything. I passed with a C. That was good enough to move on to the next class.

I did the next class [elementary algebra]. My elementary algebra professor was total shit. She yelled, you could tell that she didn't want to be there teaching, she was always grumpy and if you asked questions, she kinda yelled at you. I'd say now that she was the worst math professor I've ever had. She made people feel dumb. We complained about her all the time, and some people reported her to the Dean. Nothing happened though that we know of. [I felt] not motivated, hopeless cause I was putting in the work and not getting any positive feedback at least. I would study all the time, I would get help from tutors, and I was still doing pretty average. And so, I just thought, "Okay, well this is how it's going to be. It's disappointing, but I guess this is just the type of student than I am." That was how I felt the first year of my math class that I took, the pre-algebra and the [elementary] algebra classes. I felt like a failure. Even though I was back in school doing a good thing or whatever, I still felt like, "Man, my best isn't good enough." I passed elementary algebra with a C.

After that year, I took what's called the intermediate math algebra class, and for some reason when I took that class, it's like, I honestly feel like a switch was turned on. I credit on how that particular professor was. Because when he was giving his lectures I would write down my notes, and I would do quizzes and I was like, "Oh, I know what he's talking about. This makes sense. Oh, I know how to do this," or "I don't know how to do this," but I would study or I would practice it and then I would do really well. I would take an exam, and I got an A. That was my very first A ever. Even in high school, that was my very first A. I was like, all of these past two math classes that I was doing very average at, it's all suddenly just making sense. It’s all tying in. That was the very first time that I actually felt proud of myself, and I saw that all the studying and the work that I’ve been putting into the previous math classes, I started seeing it pay off. That got me really excited for that particular class. Just when the professor would do the lectures, I just understood everything. Not crystal clear. I still had to practice, I still had to study, but everything just started making sense. I knew how to do the basic things. I would still get help. I would go to the tutors, I would still ask the professor questions, but I was ... in that class, I was to the point where I could turn to the student that was next to me or behind me, and I could explain to them what was happening. If they needed help, I was able to help them. I even went back a few years later, and I told the professor, that same professor, I told him, “Hey, your math class is the one that I actually really liked and I really understood it, and I think you’re a really good professor.” I told him a little bit of my experience. And he told me, “Or maybe it’s not that I’m a good teacher, maybe it’s just that you’re in a position to actually receive all of this information. Maybe you weren’t back then, maybe you weren’t last semester. Maybe just now, your mind is in a place where you really want to learn this, so you’re just learning it, you’re absorbing it.” That made a lot of sense. I guess I just never thought of it that way. I was giving him credit, but he just gave it right back to me. But after that class, I got the sense of, “Okay, I can do this. I can do this.”

I went on to the next one … to college algebra, which is pretty much just the continuation of algebra. And then after algebra, I took trigonometry. I think in intermediate, college algebra and trig, I think that’s when I started really liking it. When I just really started liking math, because it made sense and if it didn’t make sense, I enjoyed figuring out a solution to problems … It would get me excited.

That’s when I started working as a math tutor. [Before I became a tutor], I practically lived at the tutoring center. That was my hangout spot and always went to get help with my homework. One day the guy that ran the tutoring center came up to me … [it] was crazy cause I knew this guy from high school and he was part of the Mexicans at the back of the school clique … and [he] was like, "Hey, you should consider tutoring at least the lower division classes you've already done." And, [he] was telling me that the practice would only help me understand the math a lot better. I laughed and was like, "Nah I don't think so, I'm struggling and am barely passing my classes as it is." Then he kept talking about the benefits of tutoring. but I kept saying no. After like an hour, I was packing up and leaving, he put and application for tutoring math on my keyboard and said, "go ahead and fill this out, you won't regret it I promise." I got red in the face, took the application and left. Next day I gave it to him. I got called in to be interviewed, got hired and I never regretted it. I feel like he [tutoring center director] believed in me when I didn't and I'm very grateful to him.

[Reflecting back to when Kitatoi realized she knew the tutoring director] … I was shocked and embarrassed that I judged all of them [Mexicans that hang out in the back of the school] because he was part of them. But, I was also pretty fuck'n proud that at least one of them ended up getting an awesome career … he [tutoring director] went ahead and got a master's in mathematics.

After trig, I went into calculus and that's a series of three classes, and I took all of those. I struggled with them also like at the beginning, but I learned where to get help, I learned how to get help. I had already learned how to manage my time by the time I got to those classes. It was a good transition of learning how to study, how to manage my time, how to ... pretty much how to be a good student so that I can learn. I started tutoring the lower division math classes. Then, as I passed my other math classes I began to tutor in those classes. Then got to a point where I tutored from pre-algebra to calculus III. I really enjoyed tutoring. I stopped working [there] when I started [Research State University]. I miss helping out the students. I learned how to explain things from a student point of view … students would appreciate it. And, I was having fun and my confidence was way up. It was a very comfortable place to be even when we didn't know how to do something because we were there to learn … it was like a community effort …

I took all of the English classes … I was taking all the general classes. Math just became something I learnt to get good at. I saw it with [my] kids. When they started wanting help with their homework, they would come and ask me, and I was able to help them not just with math, but with their English classes, with their history classes, with a bunch of science classes that I had already taken. I already felt like, "Okay, this is what I came to school for. I'm done." This was my goal, to be knowledgeable so I can help the kids with their homework. I accomplished that, and I was like, "Well, okay, well I'm just going to keep going with this. If I can get this far, I want to see what more I can do." I was taking all the general classes, but I was also looking into [the questions], "What am I interested in? What am I not interested?" I took the psychology class. I was thinking, "Oh, maybe I'm interested in psychology." It turns out I'm not at all. During my whole time in the community college, what really was just interesting to me was my math and my science classes.

I knew I wanted to do something with math. I didn't know what, but I wanted to do something with math. I needed a science class and I decided to take a chemistry class because it involves math and it involves how things are made, and that's something that has always piqued my interest. What are things made out of? I took the chemistry class, and that was one of my favorite classes that I have ever had. It really got into what happens when you heat things up, how the light spectrum works … When you turn on a light switch, or when you're cooking something, how do rainbows get formed? All of those little things that we see all the time, but we just don't really think about, what's actually going on. That class addressed all of that. I just felt like I wanted to learn everything about chemistry. I took another semester of it when I didn't have to, because the only requirement for graduating was one semester. But, I took the second semester because I was just really, really interested in everything that they were showing me and everything I was learning in that class. I was told by my counselors and my professors that I talked to that pretty much once you get to your chemistry classes and your physics classes, that will kind of indicate if some kind of engineering was a good match. That [chemistry] class changed my whole perspective on everything around me once I took the chemistry class, I was towards the end of my community college years. I wanted to do something that I was really interested in … I really enjoyed the class, and my chemistry teacher would tell me, “You could use this in the real world. You can get a job in the real world dealing with doing a lot of chemistry.”

At that point, I got in my head that I wanted to do something in material science engineering because it had lot of chemistry and had math. Based off of how I’m really curious about how things work, what things are made out of, all of that stuff, I thought, “You know what, material science engineering is probably what I want to go into.” I was thinking about transferring to a university to actually get a bachelor’s … I started thinking, “Okay, I want to go further. I want to actually get a bachelor’s degree. I would like to be a material science engineer. That would be really cool.” Then I went to my counselors, getting advice, and they told me, “Okay, you want to transfer? These are some of the classes that you need to take in order to transfer.” I had to take a physics class … physics … I felt like that was going to make or break my decision of going into a science field or … just going to stay … teaching math, like maybe just being a math teacher. I was already thinking of mechanical engineering or material science engineering, one of those two. If I do really good at physics then that’s it, like my path is set … it was kind of like a make it or break it point … Because I was already at a point where, I have to choose what I’m going to major in so that I can focus on that and get a degree, get a job.

I didn’t want to admit it. I didn’t want to think about it because I was intimidated by physics. I was just still doubting myself until I went to physics. I left that one as my very last class that I needed. I wanted to do everything else first and just leave physics to the end because I honestly just thought I was going to fail at it, because only smart people did physics. I just felt like I wasn’t ready for it with my math classes. I didn’t feel like I was at the level I should be. I worked at the tutoring center for ... at that time, I was already working there for … three years … and I would see the people that would go into the tutoring center for the higher division classes for physics and they were just really smart people … really smart and mostly guys, meaning they get straight As. There's always talk of … "Oh, that was really easy. Oh, I got an A on the test. Oh, I didn't really take notes because I don't have to take notes. I can just memorize everything." Or, "I already know all of this stuff." I have always associated [that if] you get straight As, you must be really smart, which I've learned that that's not really the case anymore. But, at that time, that was my mentality. I would think these younger people that are taking these physics class[es], you just need so much dedication, and you just need to study all the time and that's pretty much your life, and I can't do that. Because again, I have three kids. I cannot just dedicate my entire life, my entire day to one class or one subject and be good at it. These people, they were just known to be really intelligent people, and there were very few of them ... maybe out of a class of 20, only five people, six people would do really, really well. I saw that and I thought to myself, "I'm not going to be one of those people that does really well ... I don't want my self-esteem to go back down." I was intimidated by those classes.

A lot of the people that would go to the tutoring center or that were working as math tutors, they would complain that the physics teacher [at community college 1], he wasn't a good professor. He didn't explain things. He pretty much picked a few students that he knew were going to succeed, focus on them and everybody else was kind of fucked … I already had it set up in my mind, "Okay, if this is a path that's going to make me fail, I'm going to avoid that and I'm going to go over here [to a different community college] and take it at [community college 2] …"

But, once I got into the [physics] class, I just started doing really well with the concepts. Out of everything that I have taken in college, even more than chemistry, that [physics] was way more fascinating and way more interesting than chemistry. I just started being really interested ... it was really fascinating. All of the concepts. I took the two years that were required of physics at the community college [community college 2], and that's when I really made it more concrete that I wanted to go into mechanical instead of materials because I liked the whole how things work, how do you fix things, how do you make things move, how do you make things work, pretty much. But, I was hesitant because I've always known that it's a very male-dominated field, so that was also intimidating.

The first thing that I would think of when I would think of mechanical engineering, I would think a mechanic shop. I would think of my dad covered in oil because he was under the hood of a car … I don't want to be a mechanic. I don't want to be under the hood of cars. You never see women technicians fixing things. I just always saw that if it was something to do with fixing and it had to do with tools or anything like that, it was always a guy. That's what I would think mechanical engineering was all about. It was about working in an auto shop and being under the hood of cars, and that's not really something that I wanted to be doing. I would hold back on that idea because of those things. I also thought it was a field where you just have to be really knowledgeable in that field. But, I didn't really think I was capable of reaching that level that you needed for those types of classes. It was once I got to physics [at community college 2]. I went to that class and it was mostly guys as I expected. Out of 12 people, there was four girls. I literally thought I was going to be the only girl. Now that I learned that I'm not, "okay, this isn't going to be that bad." Out of those people, only eight of us stuck to the end and actually got through the whole class. It was four guys and four girls and I was one of the girls. That changed my mind to, you know what, it's not purely guys and you're just going to be the only girl. It wasn't like that at all. I started to think, it doesn't matter. If I'm one of the few girls, I just decided I'm not going to let it get to me. This is actually what I want to be doing, and there's no reason to be ... that's not a good enough reason to be held back. I feel like I did just as well as the guys did in my physics class in the first one and the second one, so I felt if they can do it, then I can do it and I was able to do it. That whole mentality of this is just for guys, it started going away … little by little. After those classes, I was getting ready to transfer to a school for mechanical engineering. I had already been six years in community college, and I was starting to feel like I was stuck there … I'm just going to be here forever. I didn't really feel like I was advancing. I took the very last class I needed in order to transfer and got accepted to [Research State University].

[Kitatoi at the time of this interview was in winter quarter, her first quarter at Research State University] I have three classes right now … It's pretty rough right ... I don't feel good about my classes. I'm having a really hard time adjusting from six years being in the semester [system]. I'm also having a hard time adjusting to the workload that each class requires, and [my] kids, and just personal stuff. But I really like my classes, but I'm not really doing very well in them, as well as I want to be doing. I don't think it's because of the material. My classes right now are more in depth physics classes, and I'm really interested in my classes. I really like them. I think they're fun. I am just having a hard time adjusting to doing everything in the very, very short amount of time and very fast pace amount of time. I just feel like I don't have enough time to do everything that I have to do in order to be really successful in these classes or even just enjoy my time at the university. The whole time that I have been in the community college, I have learned to be a good student. But now, all of a sudden … It's very fast pace, and I'm just having a hard time keeping up with everything. I feel like I'm behind all the time, and if I don't do well in something, I don't really have time to learn what I did wrong because we already moved on … everything is due just one right after the next for three classes. I'm messing up in my exams. I do well in the homeworks, I do well on quizzes, I ask some questions… It's frustrating because I know these concepts. Then, it comes down to exams, your whole grade is based off of two, three exams. You have what, an hour to figure out all of these problems quietly on your own. I'm not at my best thinking when I'm in that type of situation, so I don't do well in the exams. I'm not having a good experience with being in school … I'm not enjoying it at all. What I mean … by enjoying myself … is I really like these concepts that are being taught. I just really want to understand them … because I'm interested. This is something I want to know. I want to learn this. I want to enjoy it, but I'm not.

[And] I don't have time to do things with [my] kids. I have my mom picking them up from school. I have my sisters picking them up from school. Their dad takes them to school. I'm gone every weekend because I have to study. If I stay here in the house, I'll do things with them [kids]. I want to talk to them. I want to hang out with them. I want to go have lunch with them. They also have homework; they also have issues. I have two teenagers now, and a 10-year old. If I'm here, I have to be here for them. I haven't been doing that very well. I've been missing out on a lot of the things that the kids are doing because I'm just too busy trying to pass classes ... it sucks because I just miss [my] kids. I'm not with them. Even with that, I'm not doing very well in the classes. I feel like I'm wasting my time … and I'm messing up with being a mom …

My winter quarter was the first quarter that I was at the [Research State University]. I ended up passing with the minimum requirement to pass the classes. One of the classes, to pass the class, I needed a D minus, and I got a D minus in the class … I got a C in those two classes … In the winter quarter, my GPA dropped a lot. [The university] actually sent me an email like, "Hey, you got to make sure your GPA doesn't fall below a 2.0." I enter my spring quarter, and I bring it down to two classes [enrolled in two classes]. But, I still had issues with this going by really fast. And what really counts in this class are just your exams. And I end up passing my spring quarter with pretty low grades … I have a C in one class, and I think a D in another class. I still got pretty low grades, but I thought I'm not failing the classes. I got the time management thing down. I went from three classes to two classes. I did the whole study with people from the same class. I stayed more at the library because I figure I can get a lot more done if I'm on campus then if I'm here at the house because kids ... I mean I stayed there until midnight when they closed the library, the whole quarter.

A week before summer classes were supposed to start, I get an email from the Dean of my department, saying that I have been dismissed from school … my GPA was below a 2.0 … and I lose it. I break down. That was my hardest that I've tried. And I get dismissed. It took me weeks to kind of wrap my head around that because I'm like, "Okay, yeah, my GPA was low the very first quarter. Fine. The second quarter, I did things to fix it, to make it better, but it still wasn't good enough. My GPA is still low." I'm like, "Fuck this. They're just going to kick me out of school? I tried my best. I can't try better because that was literally my best. And I'm just not good enough." Because I was dismissed, financial aid doesn't cover if you have less than a 2.0 GPA … I was kind of like, "You know what? Fuck it … I'm not going to go back to school because I was just not good enough. What I'm doing is not good enough. So, I'm not even going to bother with it. I need a job. [Ex-husband] needs to leave here and make his own life. He can't live here forever. I need to pay for this house. I need to pay for bills. I just need a job." I started job searching. I had it set in my mind, I'm just not going to do school because first of all, they kicked me out. Second of all, I can't try anymore than I already tried. I could keep doing the same thing, and yeah, okay, my GPA went up, [but] it wasn't good enough. There's really not much more that I could do, but I think what got me out of that [mindset] was that I felt like I had already done so much, like so many years because it took me a long time [in community college]. I was getting a lot of emails in the meantime from the school … "you have a chance to appeal the dismissal, and you have a chance to appeal the financial aid. You just have to fill out a form." [I thought] If I don't give it one last chance, I'm going to regret it. They already kicked me out. I have no more pride. I'm going to do this appeal … It's only a form. And, then I got an email "your appeal has been granted." After another week, I got the financial aid appeal approved also. Okay, so, now I can go back to school … I'm able to go back to school in the fall, which I planned to … But it's literally my last chance that I have to get my GPA up, which it kind of scares me because last quarter I really did try, and it didn't go up as much as expected.

I'm really worried that no matter how hard I try this coming quarter; it still might not be good enough. I definitely feel like the quarter system … I think it's designed for younger people that are fresh out of school and still just have school mentality, and that's all they have to worry about. But, it's definitely not meant for older students. I just pretty much want to transfer [out] because I feel like [Research State University] … they don't give a shit about people's situations. They think I'm lazy. They think that because I don't fit the numbers … [recalling an experience prior to the dismissal] because I talked to my advisor person, and he was telling me about statistics and generally people do this … Generally, students are like this … And I told him, "Yo, how many of these students have three kids and are close to hitting 40? How many of your students are in my situation? None, right? So, that doesn't make sense to me, and it's not fair that you're holding me at these standards just like these other 20-year old male students with no kids. That's not fair …" I kind of have it set in my mind [Research State University] just doesn't want me there because I don't fit. I don't fit the numbers. The students that I know, especially in my classes, the majority of them are guys. They're young guys. They don't have kids. They don't have rent to pay. They live with their parents … they're usually financially pretty well off. They're not students in my situation. Even some girls, the few girls that are there, they're young. They're in their 20s. They don't have kids. So, they're able to be there full-time. But, even the fact that I need to be there part-time … the people at the financial aid [office], the professors that I talk to, they kind of look at me like I'm doing it wrong, like I'm not being a good student. I feel like I'm the student that doesn't fit in. I'm the student that I'm not like everybody else … I just feel like … you're not here full-time, financial aid punishes you… because they can't help you … you're not here full-time? So, there's less classes that are available for me or that work around my schedule, or people get together from my class at times that I'm not able to make it, or I have to really neglect the kids so that I'm able to make it.

The dean of my department, he was actually one of my professors the very first semester. I talked to him. I told him my situation. And, [he] pretty much [implied] if you can't handle this major, there's other majors that you could consider. The help that I feel like I should be getting, it's not there at all. I feel like I have to pretend like I'm a 20 something year old with no other responsibilities, so that I can feel like I belong in these classes. It gets to me. There should be help for people like me. I shouldn't be punished because I'm not able to be full-time. They [faculty and staff at the university] pretty much like to see numbers. If their students are doing well, then it's good reputation for the school. If there's one bad apple, they tend to get rid of it, and I feel like that with me. So, I just feel like yeah, they don't want me there, or I'm not good enough for that school. I kind of just even regret going there, but now I'm stuck there. At this point, it's because I'm just stubborn. I mean they took me back, and financial aid [office] did the whole appeal. But, at this point, I'm just like, "Fuck you. I'm going to go back." I'm not excited to go back. I'm not even grateful that they gave me another chance because I don't feel like I should've been put in that position in the first place because I'm not slacking off. At that point, I was like, "Okay, maybe I'll just give it one last shot just so I won't regret it later. You know, maybe I could have done something else."

[conversation with Kitatoi before the start of fall quarter of her second-year] I can't change to [State Teaching University] 'cause my GPA is too low. I was hoping to even change my major to civil or environmental but [Research State University] doesn't offer civil. They offer environmental, but it will take me an additional year just to take extra chemistry classes, which I'm not gonna do. I been just thinking that maybe I can change my major to materials science engineering because a lot of the classes are similar. I'm looking at my options of what I wanna be doing with the degree by the time I'm done. I'm taking the classes that I overlap those two majors so I won't be taking classes I don't need. I want to set myself up with a job.

[Kitatoi has just finished her fall quarter of her second-year at Research State University after being reinstated] [The] quarter just ended like a week ago. I haven't gotten my grades back yet. [The classes I took were] pre-modern science and technology engineering a required class [and] material science and engineering. Those were a lot of fun. I think this quarter, it went pretty well. [My] kids' chang[ed] school[s] … [my daughter] started high school and the high school is like two blocks away [from my home]. I moved him [my 10-year old son] over to [different middle school], which is also walking distance [from my home]. That freed up a lot of travel time … study time. The times that the classes are available, I don't have to worry about having that break in-between the middle of the day. Normally, I would finish a class I'd be like, "Sorry I can't stay, I can't go to office hours, I can't stay and study because I had to go pick up the kids." I think that helped a lot with adjusting to the quarter system. I think I found a way to make it work, and I actually like it. I'm actually enjoying it. I think it's still too fast … the classes that I take [sic] this past quarter. The professors had the PowerPoints, so I was able to download the PowerPoints and I got this Notebook computer thing where I could just write on my computer. I just use this pen to write on the screen. I saw some people from my classes, they were using it [notebook computer], and I saw they were taking notes way more efficiently than how I was taking notes. Then, I just figured, I'll do what they're doing. At least this past quarter, that has helped a lot. I could also record the lectures. [In previous quarters], they [professors] didn't upload their material beforehand. I would've printed them out or something, but they didn't. I kind of paid more attention to class rather than trying to copy every single thing down because I already had [downloaded] the PowerPoint lecture. I would just add to it. So, I feel like I got more organized. I think those were two big things were able to help a lot. If next quarter my professors don't upload their notes … if they don't have that same method … I'm just going to have to figure out another way to be as successful. I think I found a way to make it work, and I actually like it. I'm actually enjoying it. I think it's still too fast, but I'd rather stick with the quarter system. The only part that I don't like about the quarter system is I [can't dive deep into course material], but I kind of just learned like, "Oh well, that's the way it is." I don't really have time to go really deep into the topic as I would personally like, but, "Well who cares? That's the way it is. That's part of adjusting."

My classes … they're like 8 AM classes, so I have more of the day to get in contact with the professors or study [and] still get back home in time to just hang out or talk to the kids. One of my classes the kids had like a week off, so I actually took [my daughter] to one of my classes or else she was going to stay in the house by herself because the boys weren't here. I was also kind of worried like, "Are they going to tell her like, 'Oh, you can't be in here?'" Because at [Community College 1], they didn't let kids in the classrooms, or the tutoring center. I had this one boss and she was like, "Yeah, no. We can't have kids in there because they're a liability.

You have to be outside in the hallway." I was kind of a little bit worried. So, I took her, and the professor, he was really happy that there was this little girl there. I sit up in the front, like first row. It's like a class of like 250 people. [The] lights [were] on because he doesn't turn off the lights, and I sit right in the front of his desk. He saw her and he's like, "Oh my God." He was just excited that there was a little girl there. He was like, "Yeah, your ... mom, she's a really hard worker. She's a really good student" I feel like that helped me a lot with like, "Okay, maybe there are people that are accepting of, 'Yeah, I'm not a 20-year old with no kids' type of thing," so that helped a lot. It kind of made me feel better with, "Okay, I'm here in your class and I have kids. Here's one of them."

After I took her, I think he felt more comfortable talking to me. He was like, "Oh yeah, I also have a daughter." I don't know … it just showed a little bit more ... closeness. When I was walking around in campus [after taking daughter to school], I was just like, "Man, that'd be cool if my kids, even if they don't come here to this school, they go to a school and they'll have everything that the campus has to offer, like the restaurants, the lounges, all the libraries." I've just been able to share with the kids … how I study … how to study or ... putting in more time and effort … what has helped me with being organized or getting things done … [and they are] old enough to take in what I have to say and even apply it to their school, their studies, their way of studying. [I've said,] "If you need to wake up earlier to do last-minute studying before a test, then that's what you've got to do." I think that's a good thing that has happened. It's [my ability to give advice about school] all been because of the experience. They're not like, "Oh, she doesn't know what she's talking about" or, "She doesn't know how hard physics is" because they know that I do. I think that's a positive thing that has come out of this [university experience].

[I asked if she saw herself as someone that can do engineering] I think so … [when] I'm doing something and it's not working out." I tried to adjust or fix it or change things around so that I could have a better outcome, and this past quarter which is my third quarter in [Research State University], I just changed a lot of things around

> and I saw like, "Oh, this is working." When it comes to figuring out an issue, figuring out a way to solve it and for something to be more effective or have a better outcome, and I feel like that's what I did. I feel this past quarter is the first time that I felt, "Holy shit, this worked." So yeah, I definitely felt like somebody that can take a problem, figure out the kinks of it, adjust it, change things around, and make it better.

5.13 Discussion

The third and last interview I had with Kitatoi, she mentioned that she was waiting to receive her fall quarter grades. That quarter Kitatoi was reinstated after being dismissed for having a GPA less than a 2.0. I reached out to her a few weeks later via email to ask if she managed to raise her GPA. Kitatoi replied, "this quarter I managed to get from a 1.7 to a 2.1. I got an A and a C in my classes." She plans to continue to the winter quarter as a part-time student retaking Statics to earn a higher grade and introduction to circuits. I plan to continue following Kitatoi's journey until degree completion; her current plan of study requires that she complete ten courses before being eligible to graduate.

Kitatoi's journey into engineering did not begin playing with Legos at a young age or enrolling in summer STEM camps. Nor did it emerge through advance high school math/science preparatory courses, a shared account among traditional-aged students studying engineering (Strutz & Ohland, 2012; Verdín, Godwin, & Ross, 2018) and the experiences of the three participants whom I did not focus on in this study. Instead, her pathway into engineering was against environmental constraints and, in large part, was a result of her agency (i.e., the actions and choices she made in response to and against external influences).

I discuss the findings in three sections. First, I situate the sociohistorical factors that shaped the trajectory of Kitatoi's lived experience with a particular emphasis on the effects of environmental factors on student development and identities (Torres, Hernández, & Martinez, 2019; Torres, Jones, & Renn, 2009). Following, I answer my first research question, "What are the experiences that shaped how a Latina, first-generation college student authored her engineering identity?" I discuss these experiences in the context of her years at community college and the year and a half she has spent in her bachelor's granting institution. Lastly, I discuss my second research question, "What experiences prompted Kitatoi to negotiate her multiple identities?" To answer this research question, I acknowledge the ways of being like an engineer that are imposed onto students and how those ways of being conflict with who Kitatoi is, thus prompting identity negotiation.

5.13.1 Sociohistorical Factors that Shaped Kitatoi's Trajectory

In Kitatoi's narrative, the imposed environmental constraints in the education system when she was an adolescent had a long-lasting impact on how she saw herself as a student in STEM. Kitatoi's reflection of her life's course and decision to change the trajectory of her life was a powerful emancipatory act towards reclaiming her agency, towards reconstructing her environment, and a choice driven by the desire to reshape how she saw herself (i.e., seeking identity-congruence). To be clear, Kitatoi's narrative is not a story of a high school drop-out. In fact, she graduated from high school, barely meeting the graduation requirements and with minimal academic preparation. In her words, "I didn't get anything out of high school. I just got the fuck out of there." Kitatoi's reflection revealed how disempowered she felt as an adult in society, how her agency had been hindered due to an education system that failed to prepare her and how this, in turn, would affect her children.

Kitatoi's story is not uncommon, in fact, scholars have long documented how the public educational system has oppressed Mexican American students (Ballón, 2015; Rumberger & Rodríguez, 2010; Valencia, 1997, 2011). Kitatoi began high school in Southern California in 1997 against the backdrop of a master narrative of Mexican Americans' lack of educational attainment, achievement, educational value (Valencia, 1997, 2004) as well as state initiatives prohibiting bilingual education, which shaped how linguistic minorities were viewed in society (García, Wiese, & Cuéllar, 2011). Valenzuela's (1999) extensive ethnographic account of high school students observed how students at one predominately ethnic minority school were subjected to linguistic and cultural divestment. The social structure (i.e., policies and practices) were imposing an assimilationist way of being, i.e., White educational norms. The statewide discourse and public perception of bilingual education of students who were English language learners were fiercely contested issues between those in power (i.e., California legislators) and the communities who needed the benefit of bilingual education. The debate between offering bilingual education and the negative perception associated with people who were English language learners impacted how Kitatoi saw herself and who she wanted to become.

Kitatoi recounted teachers' relationships with her as inauthentic, lacking care, and compassion for her educational struggle. Her teachers tended to be more concerned with the content acquisition as opposed to Kitatoi's subjective reality, this was apparent in her experience with teacher to student interactions, "Some me regañaban [would scold me] that I was falling behind or I'm at a lower level than I should be at or tell me that I needed to do something about it." In many ways, teachers were interpreting her lack of content knowledge as a form of off-putting behavior—signifying that she did not care and that her lack of academic preparedness was her own fault (i.e., blaming the victim). The high school Kitatoi attended was guilty of reproducing inequalities among students by preparing certain types of students differently from others. Her experience in high school was rooted in long-standing racists stereotypes about Mexican Americans as indifferent towards and devaluing education, denoting a form of deficit narrative imposed on her (Valencia, 1997; Valencia & Black, 2019). Kitatoi, as an adolescent, was impressionable and vulnerable to the single narrative she saw in her surroundings, unaware that society had systemically disempowered and disenfranchised people like her (see Gonzalez, 2013; Tejeda, Martinez, & Leonardo, 2000; Valencia, 1997, 2004). Scholars Solorzano and Solorzano (1995), Valencia (2011), and Ballón (2008; 2015), among others, would argue that the students in these ESL classes had unequal schooling conditions (i.e., ability grouping, curriculum differentiation, and low expectations) that stunted their opportunities by offering a curriculum that only prepared them for low-paid and low-skilled jobs. Additionally, the ESL students were receiving subtractive schooling by having resources removed (i.e., regular-tracked courses and college preparatory courses; Valencia, 1999). Kitatoi's refusal to enroll in ESL classes was a resistive act, not on the part of being bilingual or Mexican American, but on the positioning and unequal opportunities afforded to language minority students in those classes. Her perception of Mexican Americans and people with English as a second language was constantly at odds with who she wanted to be, in large part due to an imposed reproduction of a deficit perspective of ESL and Mexican American students that dominated the discourse. The master narrative of how Mexican Americans were positioned in society was rooted in deficit and racists views, intended to systematically disenfranchise a growing community in the Southwest (Solorzano & Yosso, 2000).

Kitatoi's feeling of disempowerment as well as feelings of being disregarded and overlooked by her teachers fractured her agency and led her to withdraw from pursuing higher education. Systemic inequalities imposed onto Mexican American youth, discussed by scholars

(Stanton-Salazar, 2001; Valencia, 2011; Valencia & Black, 2019; Valenzuela, 1999) allowed Kitatoi to enter high school underprepared, as she recounted in her story, that she was “talking, reading and writing just very little maybe at an elementary level … but not where you’re supposed to be at a high school level. While Kitatoi graduated from high school, she “understood very little in order to pass, but I don’t think I learned anything.” I would argue the imposed academic self-concept of a struggling student became overpowering and limited her ability to succeed. Kitatoi’s environment constrained her to an academic self-concept of a struggling student. It took Kitatoi’s agentic capabilities for her to act on her environment and push against the master narrative imposed onto students like her. She declared, “I don’t want to be like that anymore.” Before Kitatoi could begin to imagine herself as a capable learner of engineering, she needed to dismantle the imposed academic self-concept of a struggling student. Through an agentic act, Kitatoi navigated out of an imposed environment that had left her as an academically ill-prepared adult into an environment of her own interests and choosing.

Despite her depressed academic preparation, as a result of the education system that failed her, she enrolled in a local community college ready to beat the stereotype that Mexican American youth were “not going to get very far.” After a semester, her academic trajectory took a turn, “I decided that I was just going to get married. Wasn’t going to do school, was just going to get married and have kids and that that was going to be my life.” However, later on, she re-enrolled a community college determined to “tackle the one thing that I was most intimidated by … I started with math,” which inadvertently steered her towards an engineering pathway.

Kitatoi’s reflection on her experiences, feelings, and stories was important to understand how sociohistorical factors shaped her trajectory. Throughout her trajectory, her agency was both constrained and enabled, constrained as a result of the master narratives that imposed a certain way of being in the world and enabled when she actively refused these narratives. Kitatoi’s story offers a view of agency that was both enacted and suppressed by environmental factors (i.e., environments that were imposed, selected, and constructed). The dance between constrained and enabled agency ultimately shaped how Kitatoi saw herself in relation to learning and being a student. Kitatoi’s identity, albeit imposed due to environmental factors, at this point in her life was that of a struggling student. In the next section, I discuss how Kitatoi’s reconstructed agency allowed her to re-enroll at community college, which paved a pathway towards studying engineering and ultimately reshaped her perception of herself as a capable learner. In sum, to understand how Kitatoi came to see herself as someone that can do engineering, it was important first to understand the imposed environment she agentically navigated out of and the environment she chose.

5.13.2 Enacting Agency: How Kitatoi came to see Herself as Someone that can do Engineering

The route to engineering is layered with hurdles—students must simultaneously see themselves as mathematics and physics type of people to feel as though they can do engineering (Godwin, Potvin, et al., 2016), this connection is also evidenced in Study 2. Kitatoi chose to tackle one of her biggest fears, mathematics, not because in that stage of her life she had a desire to pursue a career in engineering or mathematics but as a result of enacting her agency to control events that would affect her life. While mathematics was "one of my biggest fears," Kitatoi made a conscious decision not to allow mathematics course requirements to constrain her academic progression. Based on Kitatoi's prior experience in high school, it seems her desire to get As on exams was a desire to shed the perception of herself as a struggling student or someone who did not learn anything in high school. Kitatoi's participation in mathematics, in large part, was to reshape how she saw herself (i.e., as a capable learner). Unfortunately, her grades initially did not reflect who she wanted to be. She said, "I guess this is just the type of student than I am."

Although her strategies indicated that she was doing everything to succeed—attending classes, constantly practicing problems, and getting help—there was still a barrier to overcome. Kitatoi's interactions with her mathematics instructors were both enabling and constraining. Kitatoi stated, "My pre-algebra professor … wanted us to learn, would have good explanations and plenty of examples." Learning mathematics and the way students position themselves in relation to mathematics is constructed by both the students and instructors (Boaler & Greeno, 2000). Kitatoi was placed in an environment where her willingness to learn was congruent with the instructor's willingness for his students to learn. Therefore, although she was not performing at the level she had hoped for, she continued to the next mathematics course.

Boaler and Greeno (2000) posited that the types of mathematical tasks, teaching techniques, and learning approaches teachers use enable or constrain students' beliefs of seeing themselves as math type of people. Students' perceptions of themselves as mathematical learners develop in and through social practice. However, certain environments can have a constraining factor on seeing oneself as a capable mathematics learner, which is where Kitatoi found herself in her second semester in college as she recounted her experience in Elementary Algebra, the "professor was total shit … you could tell that she didn't want to be there … she made people feel dumb." The imposed learning environment negatively impacted Kitatoi's self-concept and affective beliefs. She stated that she felt "embarrassed … not motivated, hopeless 'cause I was putting in the work and not getting any positive feedback." Understanding the interaction with Kitatoi's elementary algebra instructor made it clear why she resigned herself to be the type of student that barely earned an average grade in mathematics. She finished her first year in community college in a state of disillusionment by the performance marks she was receiving, the lack of positive reinforcement by her instructor, and a belief that "this is just the type of student than I am," reinforced once again the identity of a struggling student.

Nevertheless, Kitatoi persevered despite an imposed negative learning environment. Her agency to control the events that affected her life, despite environmental constraints, propelled her to enroll in the mathematics course that followed elementary algebra. Studies have found that a large portion of students who enter community colleges make little progress towards certificate or degree completion, specifically noting that completion remains correlated with socioeconomic status (Goldrick-Rab, 2010; Summers, 2003). Kitatoi's agency, coupled with her intense desire to persevere, was sufficient to break down barriers as she moved on to the next mathematics course (i.e., intermediate algebra) where she was supported, and the "switch was turned on."

Kitatoi's fleeting effort her first-year left her development as a competent mathematics person contested, evident in her account when she said, "my best isn't good enough," when she received Cs in her mathematics courses, even though she "studied her ass off." However, her ability to obtain an A in her intermediate algebra exam was the turning point, moving from a struggling mathematics learner to a proud mathematical learner. Kitatoi's agency, coupled with her perseverance to learn mathematics, afforded her the ability to perform her competence in the domain and eventually come to see herself as a mathematics person. While her first-year coursework was not reflective of the type of mathematics student she wanted to be, Kitatoi was determined to reshape who she was to be congruent with who she wanted to be. She said, "I had an 'I'm not gonna fail again' attitude … I'm gonna get good at it no matter what."

Following her experience obtaining "my very first A," and her ability to explain to others what was going on in the class, Kitatoi continued to take the entire sequence of mathematics courses available at her community college, stopping after Calculus III. At this point, Kitatoi managed to leave behind the identity of a student who struggled and took on the identity of a thriving mathematics learner, as she stated, “I was to the point where I could turn to the student that was next to me or behind me, and I could explain to them what was happening. If they needed help, I was able to help them.” Her agency to act against a system that failed her allowed her to reshape her student identity and subsequently start to see herself as someone that can do mathematics. Kitatoi eventually constructed an environment where she felt recognized as a competent mathematics learner; she became a tutor for mathematics classes ranging from Pre-Algebra to Calculus III. Being externally recognized as a competent mathematics type of person, by the tutoring center director, intermediate algebra instructor, and her peers whom she helped, supported her development of an identity as a competent mathematical learner moved Kitatoi from a peripheral participant of mathematics to a more fully engage participant of that community of practice. The external recognition she received propelled her to take on the role of a mathematics tutor. As a mathematics tutor, Kitatoi moved past the identity of a struggling student to a competent mathematics type of person who subsequently was receiving the external recognition necessary for identity development (Cribbs et al., 2016; Godwin, Potvin, et al., 2016; Rodriguez, Doran, Sissel, & Estes, 2019). Kitatoi stated, “I was able to explain things and the students would appreciate it. And I was having fun and my confidence was way up. It was like a community effort.” Kitatoi’s entry into the mathematics community of practice allowed her to pursue scientific courses. She took two chemistry courses and eventually took calculus-based physics. Calculus-based physics courses are considered a gateway into engineering programs (Cass et al., 2011; Tyson, Lee, Borman, & Hanson, 2007; Warne, Sonnert, & Sadler, 2019) and support students beliefs of seeing themselves as engineers (Godwin, Potvin, et al., 2016; Verdín, Godwin, Sonnert, et al., 2018). Therefore, to solidify her transition into an engineering degree program, Kitatoi needed to pass through this course series. Through her agency and the recognition of others that promoted her beliefs in her ability to understand and do well in mathematics and science, Kitatoi was able to reshape her identity as one of being a person that can do engineering.

Studies have documented that preparation in mathematics is a strong predictor of success in physics (Hazari, Tai, & Sadler, 2007; Kost, Pollock, & Finkelstein, 2009). While Kitatoi had established herself as a competent mathematics learner, her ability to succeed in physics courses was met with environmental constraints. Her statement, “only smart people did physics,” was in response to the pervasive gender imbalance in her physics courses, the constant environmental message of who can participate, the stereotype threat that continues to impinge on women's performance, and implicit bias against women's ability to excel in physics courses (Blackburn, 2017; Eddy & Brownell, 2016). It is important to clarify that within her environment, she would hear negative talks, from other students, about the physics instructor at community college 1. Thus, Kitatoi felt powerless towards being able to maintain her good student identity in that environment. Through an agentic act, Kitatoi enrolled at a different community college (i.e., stated community college 2 in her story) for the sole purpose of taking the physics course series. By enacting her agency, Kitatoi selected a different environment where she would have a better chance of being successful.

Compared to other science courses (i.e., biology or chemistry), the gender disparity in students who participate in calculus-based physics courses is significant. Additionally, physics has been found to support students' interest in pursuing an engineering degree (Sadler, Sonnert, & Hazari, 2014; Sadler et al., 2010; Warne et al., 2019) perhaps because exposure to advance mathematics content supported students' mathematics identity and in turn interest in an engineering career. For women, studies have found that they often feel a lack of belonging in these courses compared to men, in large part, as a result of the gender imbalance and male-dominated culture (Banchefsky, Lewis, & Ito, 2019; Lewis, Stout, Pollock, Finkelstein, & Ito, 2016). In general, women are less likely to participate in the calculus-based physics series. This persistent culture of exclusion makes women's peculiarity or even invisibility in the classroom heightened.

Kitatoi's confidence in mathematics was only a starting point for her trajectory into engineering. Seeing herself as a physics person was equally important for her self-recognition as a capable engineer. Kitatoi's six-year journey through community college was an empowering experience where she managed to shed the academic self-concept of a struggling student and learned to see herself as part of the mathematics and science communities of practice. Entry into these communities of practice was significant for Kitatoi's belief of seeing herself as someone that can do engineering, this was evident in her account, "If I do really good at physics then that's it, like my path is set … it was kind of like a make it or break it point." While it is evident that Kitatoi's career trajectory into engineering was not linear, taking on the identity of a mathematics and physics type of person was instrumental for her pathway into engineering. Kitatoi came to see herself as someone that can do engineering through the performance and competence beliefs she developed in mathematics, through the recognition she received by the mathematics instructor that subsequently lead her to become a math tutor, through her interest in mathematics despite not receiving high grades in the beginning, and through her agentic capabilities. Her decision to enroll in the calculus-based physics courses was an agentic act in response to the imposed male-dominated environment and her interest in learning how the world works. The interplay between interest in the content, believing in her ability to perform and understand course content (i.e., performance/competence beliefs), receiving recognition, and internalizing that recognition in the domain of mathematics and physics shaped Kitatoi's STEM identity. These experiences and Kitatoi's identification as a mathematics and physics person supported her belief that she could pursue an engineering career path.

These connections in Kitatoi's narrative are consistent with the connections drawn in Study 2 using a sample of first-generation college students who are in their first-year of college. Prior studies have found that students' exposure and affinity towards mathematics and physics are gateways into seeing oneself as the type of person that can do engineering (Cribbs et al., 2016; Godwin, Potvin, et al., 2016; Sadler et al., 2014; Verdín, Godwin, & Ross, 2018; Verdín, Godwin, Sonnert, et al., 2018). Kitatoi's retold story uncovered how the journey of seeing oneself as a capable mathematics and physics type of person is layered with hurtles, is shaped by agentic actions, and is ultimately a hard-won standpoint. I now transition over to focus on Kitatoi's experience at Research State University.

Kitatoi's journey towards identifying as a physics person supported her decision to pursue mechanical engineering and supported her claim of seeing herself as someone that can do engineering. While enrolled at Research State University, the imposed environment (i.e., quarter system and meritocratic environment) proved to be a difficult balance. Her first quarter at Research State University, Kitatoi emphasized how she was "really interested in my classes … I think they're fun" because they were more in-depth physics classes. Kitatoi's identity as a capable physics type of person supported her interest in the engineering courses she was taking; however, her current environment made it difficult to author her identity as an engineering type of person through her performance/competence. Kitatoi's challenges in performing well in her classes were a result of the courses' structure, "your whole grade is based off of two, three exams. You have what, an hour to figure out all of these problems quietly on your own. I'm not at my best thinking when I'm in that type of situation." While Kitatoi felt competent in her ability to understand the concepts, "do well in the homeworks, I do well on quizzes, I ask some questions," strategies that she had developed to sustain her good student identity. The performance markers she was largely being evaluated on, two or three exams disrupted the self-concept of a good student she had built. While Kitatoi enjoyed her courses, she felt that the environmental structure made it difficult to also perform well in the courses, in many ways, the fast pace of the quarter system pressed against her agency.

Despite the now imposed fast pace environment, Kitatoi found herself in, she continuously attempted to take control of events that would affect her trajectory. First, she switched from a full-time student to a part-time student. In her second quarter at Research State University, Kitatoi agentically decided to reduce her course load, which allowed her to focus her study time mastering two courses as opposed to three, the extra time afforded her the capability to study with classmates thus supporting her developing engineering identity. The strategies Kitatoi utilized to adjust her academic trajectory allowed her to pass her classes with the minimum grade requirement; however, she did not pass the quarter with a GPA above 2.0. Kitatoi's constrained agency was due to a lack of care from university faculty, "dean of my department … pretty much [implied] if you can't handle this major, there's other majors that you could consider" and administrators, "they don't give a shit about people's situations." While Kitatoi took control of her academic trajectory by applying strategies she felt would help her be successful, she was met with the environmental structure that required a minimum of a 2.0 GPA, thus constraining her agency and ability to author an engineering identity.

Kitatoi managed to push back against the environmental factors that were constraining her agency by enacting intentional plans towards taking control of events that affected her academic trajectory. She moved one of her children to a different school; this act would allow her ability to have more course options, attend office hours if needed, and schedule study sessions with classmates. As well, she observed her environment to develop strategies that were more effective (i.e., taking better notes, recording lectures). When I explicitly asked if Kitatoi saw herself as someone that can do engineering, she reflected back to her experience navigating through the difficulties at Research State University. She described that her ability to work through a problem, "adjust it, change things around, and make it better," supported seeing herself as an engineer. Kitatoi's authorship of an engineering identity will still be shaped and reshaped as she finishes her courses. Despite the environment of her current institution, if she continues applying the strategy of working through the problems she's facing, "adjust it, change things around, and make it better" (i.e., engineering her life's course) she may arrive at a solidified engineering identity.

5.13.3 Identity Negotiation

My second research question asked how Kitatoi negotiated her multiple identities; she is a mother of three, a non-traditional age student ("close to hitting 40"), Latina, and a first-generation college student. As Kitatoi was retelling her story, there were times when her identities required negotiation to be congruent with her own goals and sense of self, despite the imposed identities she experienced. Ultimately, Kitatoi's agency to negotiate these identities, in spite of significant structural barriers, was the reason she was able to succeed in an education system that perpetuated racist, sexist, and classist ideals. The identity negotiation Kitatoi navigated through was evident from her narrative as an adolescent and throughout her higher education journey. I present Kitatoi's process of negotiating her multiple identities as segments in the next paragraphs.

In Kitatoi's account of her experience in high school, it seems her ethnic identity of being Mexican American and having English as a second language was a point of conflict. The "vibe" she felt in her school environment and education system placed students like her in a subject position of "not going to get very far in life." Kitatoi navigated an imposed environment where the master narrative of Mexican American youths' educational outcomes and values were deficit-based. The environment imposed an identity (i.e., low-achieving or struggling student) onto Mexican American students, and that imposed identity sat in conflict with who Kitatoi wanted to be (i.e., a high school graduate and a future college student). Thus, she sought to disassociate herself from that perception by distancing herself from other Mexican American students with English as a second language. The negative stereotype against Mexican Americans created an identity conflict. Torres, Hernández, and Martinez (2019) showed that when students are presented with negative images of their ethnic group, they are subsequently influenced to withdraw from the group resulting in a cultural conflict.

In contrast, when Kitatoi saw that one of her high school peers, specifically one of the Mexicans that hung out in the back of the school had obtained a master's degree in mathematics and "ended up getting an awesome career," she changed her perception of who Mexican American's were and the educational attainment possible for people like her. Kitatoi's Mexican American identity was reshaped to be open to possibilities that her identity conflicting experiences in high school did not allow. Additionally, as Kitatoi retold her story, she comfortably switched from Spanish words and phrases to express part of her experience, which indicated that as an adult, she is not suppressing her cultural identity. I believe another contributing factor towards the resolution of being Mexican American in academia was the demographic makeup of her community colleges and the Research State University she is now attending. A recent study, using nationally representative data from the Beginning Postsecondary Students Longitudinal Study, compared institutional types (i.e., four-year colleges versus community colleges) and found that underrepresented students, women, and first-generation college students were more likely than their counterparts to feel a sense of belonging in community colleges (Gopalan & Brady, 2019). Community colleges largely serve students from underrepresented backgrounds (i.e., racial/ethnic minorities, low-income, and first-generation college students) as well as largely serve women (St Rose & Hill, 2013; Starobin & Santos Laanan, 2010; Tsapogas, 2004). Torres et al. (2019) discussed how Latinx students that grew up in monocultural Latino environments and subsequently entered colleges and universities that also have a large population of Latinos experience less of an identity threat than those who enrolled in predominately white institutions.

Kitatoi's identity of being a non-traditional student (i.e., older, not a direct admit from high school, and being a parent) was consistently negotiated throughout community college and in her bachelor's degree granting institution. Kitatoi's reality of being an older student taking a lower-division mathematics course was a point of contention. She said, "I was one of the oldest ones there, and I'm learning how to add, subtract, multiply, and divide. I learned how to divide at [age] 25. It felt embarrassing a little, even humiliating." However, Kitatoi resolved this identity conflict through exercising control over events in her life (i.e., agency). For example, when she decided to persist in taking mathematics courses despite disappointing grades. She said, "somehow, my mind was just changed like, 'It doesn't matter, I'm going to do this. It's nobody else's life. It's my life.'" The phrase, *"it doesn't matter,"* was in response to the internal conflict she felt being an older student learning material that traditionally was taught in primary school. Kitatoi's agency to change the course of her life was an emancipatory act that resolved her internal conflict of being an older student and as her narrative unfolded during her time at community college, she did not revisit a discussion of any conflict felt being an older student in the classroom.

Kitatoi's identity of being a woman and a mother seemed at odds with the male-dominated makeup of the calculus-based physics courses in her community college. Despite having completed all the mathematics courses she could take at the community college and tutoring students from pre-algebra to Calculus III, Kitatoi found herself "intimidated by physics." Her intimidation came from observing her environment and noticing that mostly male students that got straight As were taking physics courses. For Kitatoi, it was not simply that male students were perceived as competent in physics and could perform well, rather it was a combination of male students not having the responsibility of caring for children who were afforded the time to study a difficult subject. Nevertheless, Kitatoi agentically devised a strategy to avoid the physics professor at community college one who had a negative reputation among students and enrolled at community college two just to take the physics sequence. While she was still hesitant about being able to balance her responsibility as a mother and the demands of the course, Kitatoi's concern about being the only woman was resolved as she saw others like her enrolled in the course. The representation alone was sufficient for Kitatoi to feel less threatened in the physics class and allowed her to enact her agency towards applying successful strategies to succeed. She started to see herself as capable of tackling challenging courses and excelling, thus resolving her conflict of balancing the role of being a mother and a successful physics learner while in community college.

In Kitatoi's narrative, her identity of being a first-generation college student was never explicitly a point of contention; rather, this identity was always implicit in the background of her lived experiences. While Kitatoi aspired to go to college when she was in high school, the guidance and intentional college admission strategies parents often transmit to their children was not part of her reality. The negative experiences she faced in high school ultimately lead her to assume the self-concept of a struggling student, and she felt agenticless towards changing her life's course due to minimum support from school personnel and a home environment that did not provide tangible strategies towards college success. When Kitatoi re-enrolled at her local community college after stopping-out for ten years, she learned to navigate the environment through her own agentic capabilities as opposed to knowledge transmitted from her parents' lived experiences. Re-entering community college as an adult with three children gave Kitatoi the agentic capabilities needed to navigate an unfamiliar environment, this was evident in her intentionality, "this was my goal, to be knowledgeable so I can help the kids with their homework." Kitatoi resolved her identity as a first-generation college student by achieving the goals she set out to do, helping her kids with their homework, by successfully graduating community college and transferring to a bachelor's granting institution, and by agentically picking up strategies for success. Kitatoi's first-generation college student identity was subtly visible when she would share that she was "learning how to study, how to manage my time, how to ... pretty much how to be a good student." To be clear, I am not suggesting that being a first-generation college student is synonymous with not having proper time management skills or study habits. Instead I am suggesting the strategies transmitted and conversations about how to be a good student are different when an individual can draw from lived experiences (i.e., conversations transmitted and received from a knowledgeable other). Nevertheless, despite not benefiting from having had parents who attended college, Kitatoi enacted her agency towards implementing strategies that could help her be successful; this was apparent when she observed the efficiency of others' note-taking abilities and intentionally adopted and applied the same strategy. At the end of her narrative account, Kitatoi's identity of being a first-generation college student was resolved, as she walked through her university campus, admiring the environment and envisioning her children attend a university and enjoying "everything that the campus has to offer." Likewise, her ability to transmit strategies for success to her children was another form of resolution towards being a first-generation college student, "I've just been able to share with the kids … how I study … how to study or ... putting in more time and effort … what has helped me with being organized or getting things done."

Kitatoi's gender identity, *alone*, was no longer a point of contention during the time I interviewed her while enrolled in Research State University. Rather, Kitatoi's identity of being a non-traditional student (i.e., an older student, enrolled part-time, and a parent) may have been resolved while in community college because the demographic makeup of the school environment was congruent with who she was. Once she started attending Research State University the internal conflict of not being a "traditional" student became salient. Kitatoi's Research State University environment largely enrolls full-time students, 98%, and 95% of the undergraduate population is under 24 years old. During difficult moments, Kitatoi experienced identity conflict saying,"[they're] holding me at these standards just like these other 20-year old male students with no kids … I feel like I have to pretend like I'm a 20 something year old with no other responsibilities, so that I can feel like I belong in these classes." In her reflection, Kitatoi pointed out the types of identities that were normative in the engineering classroom—traditional age students, non-parents, and men. The responsibilities that come with being an older student (i.e., having children that depend on you), were in conflict with the *"good student"* identity Kitatoi wanted to maintain. To be clear, Kitatoi never blamed her children for her struggles throughout the quarter; in fact, she was often sad about her inability to enact her identity of being a good mom because she was at the library until midnight trying to support her identity as a good student. Kitatoi enacted agency to realign these two identities of being a good mom and a good student. In her fall quarter of 2019, Kitatoi's daughter started high school. Her daughter transferred to a school within walking distance from her home location. In addition, Kitatoi moved her youngest son to a middle school closer to her home. There was a simultaneous interplay between environmental factors acting on Kitatoi (i.e., daughter graduating middle school and moving to high school) and exercising her agency on the environment (i.e., her youngest son being moved from current middle school to a walking distance middle school). This environmental change had a significant impact on Kitatoi's ability to maintain her good student identity as she stated, "that freed up a lot of travel time, study time. The times that the classes are available…" Negotiating her role identities of being a mother and a student involved acting against and being acted on by environmental factors.

Towards the end of Kitatoi's retold story, she made a powerful, liberating claim to her identity of being a parent enrolled in engineering courses. Kitatoi, enacting the identity of a parent, took her daughter to her classes as opposed to leaving her home alone. She sat in the front row, right in front of her professor's desk, making a claim to her instructor and the class about whom she was. In that act of resolving her parent identity with being an engineering student, Kitatoi received the external recognition of being a good student and a hard worker from her instructor. She shared, "I feel like that helped me a lot with like, 'Okay, maybe there are people that are accepting of, "Yeah, I'm not a 20-year old with no kids' type of thing,"' so that helped a lot … it kind of made me feel better with, 'Okay, I'm here in your class and I have kids. Here's one of them.'" In sum, Kitatoi negotiated her invisible identity of being a parent by making it visible to her class and instructor thus arriving at a resolution.

Identities require negotiation when they are in conflict with the current environment or situation. Throughout Kitatoi's trajectory her identities of being Latina, a nontraditional student, a first-generation college student, a mother, and a female required negotiation and resolution.

5.14 Conclusion

Seeing oneself as a STEM type of person is shaped and reshaped through social participation and is, thus, intimately tied to participating in that community of practice (Carlone & Johnson, 2007; Gee, 2001; Johnson, Brown, Carlone, & Cuevas, 2011; Varelas, 2012; Verdín, Godwin, & Ross, 2018). Kitatoi's disciplinary specific identities are as much an outcome of her actions (i.e., agency) as it is of environmental constraints (i.e., environments that are imposed, selected, and constructed). Enacting agency involves a reflective practice, and it requires that students continually negotiate their identities-in-practice as they move towards seeing themselves as mathematics, physics, and ultimately engineering type of people. It is not possible to view learning and participation divorced from students' backgrounds and communities from which they belong. Kitatoi's ability to see herself as someone that can do engineering was a hard-won standpoint. While her journey towards being an engineer (i.e., graduating with an engineering degree) is on-going, her experiences in community college and in the year and a half at Research State University provided a different perspective of student trajectory.

Additionally, Kitatoi's narratives offered a view of how agency is enacted and suppressed that is missing in our current literature of first-generation college students. Often first-generation college students are positioned as lacking social capital or navigational skills. Kitatoi's journey demonstrated how she agentically obtained a lot of the skillsets that are said to be lacking from first-generation college students. Shifting the perspective of first-generation college students to individuals that are capable of acting on their environment and changing their life's course through their agency can help empower this group of students.

6. SYNTHESIS AND PRACTICAL IMPLICATIONS

I begin this chapter with a reminder of my positionality as this perspective influences the interpretation and synthesis of my three studies. I believe educating engineers should be for the benefit of students' personal values and life goals, not for the purpose of increasing or maintaining national competitiveness or because diversity supports innovative market solutions. Engineering education should focus on developing students' agentic capabilities, so they have the capacity to use engineering as a tool to pursue personally and socially meaningful goals. To accomplish this goal, (engineering) education needs to position students as capable agents with the capacity to impact their life and the world around them. Often, first-generation college students are viewed, both in the literature and in the broader space of higher education, as students that are lacking or in need of additional support. Positioning first-generation college students as victims of their life's circumstances dismisses their agentic capabilities both in terms of their personal agency and their beliefs about enacting change through engineering (i.e., engineering agency beliefs).

My dissertation moved away from a deficit framing and took an asset-based perspective to understand first-generation college students. In this work, I portrayed the first-generation college student population as bringing valuable perspectives to engineering. I discussed that while there are environmental factors that impinge on first-generation college students' progression, they are also agentic individuals that can act on their environment. Finally, I developed theoretical connections of how first-generation college students come to see themselves as engineers and enact their agency to expand on the framework of Critical Engineering Agency. In the sections that follow, I describe significant findings from my three studies, how they inform each other, and how they connect with the three motivations. Following, I provide practical strategies so that engineering educators and practitioners can use to help first-generation college students *flex* their agentic muscles.

6.1 Brief overview of three studies

6.1.1 Study 1 Development of a Measurement Scale for Personal Agency

In study 1, I outlined the process of revising a scale to measure personal agency and presented validity evidence that the scale is suitable for the first-generation college student population in engineering. Agency is present in all human action and it is an important concept because it situates first-generation college students as active participants of their life circumstances as opposed to passive recipients. Moreover, agentic actions afford students the capability to explore, maneuver, and impact the environment for the achievement of a goal or set of goals (Bandura, 2001). Thus, outcomes are not the characteristics of agentive acts; instead, outcomes result from students' agentic action (Bandura, 2001). The goal of this study was to develop a revised scale to capture the cognitive processes that make up agency (i.e., intentionality, forethought, self-reactiveness, and self-reflectiveness). Study 1 was instrumental in achieving my motivation to situate the first-generation college student population in an asset-based perspective. It was instrumental in building theory on how they enact their agency. Having developed a scale that captures first-generation college students' personal agency, I then made empirical claims about the relationship between these students' capacity to influence their life's course by understanding how their disciplinary role identities are developed and if their personal agency supported a disposition towards using engineering as a tool for social change (engineering agency beliefs; Study 2).

6.1.2 Study 2- Enacting Agency: How First-Generation College Students' Agency Supports their Disciplinary Identity Development and Aspirations of Making a Difference

In this study, I modeled several theoretical relationships between personal agency (cognitive processes developed in Study 1), disciplinary role identities, and engineering agency beliefs, for first-generation college students. I first modeled a second-order latent construct for disciplinary role identity, using interest, recognition, and performance/competence beliefs, in mathematics, physics, and engineering. Modeling the second-order latent construct provided an alternative approach to modeling disciplinary role identities that is unique to the first-generation college student population. All three second-order latent constructs further support the theory that interest, recognition, and performance/competence influence disciplinary role identities. Prior modeling work on disciplinary role identity, using the constructs of interest, recognition, and performance/competence beliefs, found that first-year engineering students' performance competence beliefs alone negatively predicted students' beliefs of seeing themselves as mathematics and physics type of people (Godwin et al., 2016). Similarly, when examining only first-generation college students in engineering, the construct of performance/competence beliefs was not predictive of the single measure "*I see myself as an engineer*" using path analysis (Verdín et al. 2018) but significant in a multiple regression analysis when predicting the single measure *"I will feel like an engineer in the future"* (Verdín & Godwin, 2018).

Modeling the disciplinary role identities as second-order latent constructs is consistent with the theory of identity development and provided a deeper understanding of the direct effects of interest, recognition, and performance/competence in comparison to one another (rather than using mediation). For mathematics and physics identities, first-generation college students' beliefs about performing well and understanding the subject material (i.e., performance/competence beliefs) had a positive and higher estimate than recognition and interest. When examining the second-order latent construct for engineering identity, I found that first-generation college students' interest in engineering had the highest estimate and that interest in mathematics and physics had the lowest estimate.

Developing an instrument to measure first-generation college students' personal agency (from Study 1) allowed me to model how these students' capabilities to make intentional action plans supported their disciplinary role identities and intentions to use engineering in meaningful ways (i.e., engineering agency beliefs). I found that first-generation college students' personal agency had the greatest effect on their perception of enacting purposeful and meaningful change using the knowledge and skillsets they will learn in engineering. Additionally, the effect of personal agency as a cognitive measure had the strongest impact on students' engineering identity when compared to mathematics and physics identities. Following, first-generation college students' beliefs that engineering can be a tool and resource for making an impact in their community had a greater impact on their engineering identity development compared to seeing themselves as mathematics and physics type of people. This study supported my broader motives of creating an asset-based body of work pertaining to first-generation college students and building theory about how this group of students uses their personal agency to support their engineering identity development.

6.1.3 Study 3 "I don't fit the numbers": A narrative analysis of how one Latina, First-Generation College Student Authors her Identity as an Engineer

The relationships I modeled in Study 2 emphasized that first-generation college students' author their disciplinary identities as a result of their intentional goal directed planning (i.e., enacted personal agency). As first-generation college students' author their disciplinary identities, it is important to consider the influence environmental factors have on this authorship. The work of Holland et al. (1998) reminded me that the process of authoring an identity happens over daily encounters and struggles. Torres et al. (2003) also underscored the importance of understanding how identities develop using theories that take into consideration students' race/ethnic backgrounds. Developing disciplinary role identities is a dynamic *process* of becoming and this authorship takes place against the backdrop of students' lived experiences. Therefore, the purpose of Study 3 was to understand the daily encounters and struggles of one first-generation college student, Kitatoi, and how she authored an engineering identity.

Kitatoi's narrative adds a rich experience from the perspective of a non-traditional student to the relationships modeled in Study 2. Additionally, the narrative account presented in Study 3 emphasizes how personal agency is enacted through intentional actions, forward directly planning, and reflecting on prior experiences to execute appropriate courses of action. Study 3 also emphasized how environmental factors shaped Kitatoi's trajectory as an adolescent, which subsequently lead her to take on a self-concept of a struggling student. After having her agency suppressed by environmental factors, ten years passed until Kitatoi enacted her agency towards reshaping the condition of her life's course. Kitatoi also enacted agency as she positioned herself in the mathematical figured world (i.e., classroom setting), despite mathematics being one of her "biggest fears" during high school. Once positioned in the figured world of mathematics, Kitatoi performed her competence, developed and sustained interest in the subject, and became recognized as a competent mathematical learner through her instructors, tutoring center director, and peers. Kitatoi developed an identity as a "math person."

Study 2 modeled how a mathematics identity supported the development of a physics identity. Subsequently, Kitatoi's narrative demonstrated how agency is enacted against environmental factors. The lack of female representation in physics courses and the imposed male-dominated environment pressed against Kitatoi's agency. Developing a physics identity as a competent physics type of person would be instrumental in her decision to pursue engineering, "I had to take a physics class … I felt like that was going to make or break my decision of going into a science field or … just going to stay … teaching math." Kitatoi's pathway towards seeing herself as the type of person that can do engineering in large part was supported by the developed identities as a mathematics and physics type of person. Once enrolled at Research State University, the factors that support an engineering identity development (i.e., performance/competence beliefs, interest, and recognition) at times sat in tension with her identities of being a mother, a woman, and an older student.

Throughout Kitatoi's narrative, she expressed her interest in the engineering course content she was learning; however, she found herself struggling to perform well in her courses. Additionally, Kitatoi was denied recognition as a competent engineering learner or received negative recognition as not a "good student" in subtle and sometimes overt messages in her environment. This silence or negative messaging suppressed her identities and agency. She often found herself juxtaposing her responsibilities as a mother to the lack of external responsibilities the "20-something year old males" from her class held. Kitatoi, throughout her academic, trajectory agentically navigated in and out of identity incongruent situations. The gauntlet style of engineering, which is an imposed environment, pushed against Kitatoi's agency. Nevertheless, her ability to create an environment that worked for her is a tangible example of how enacted agency can reshape environments to promote counter-spaces for learning and identity development. Kitatoi's ability to exercise control over events that affected her career trajectory, including arriving at identity congruence and managing environmental constraints, supported her belief in seeing herself as a future engineer. To conclude, Kitatoi's engineering identity is still being shaped and reshaped through her experiences, both when she enacts her agency and when her agency is restrained.

This study supported my goal of moving towards an asset-based perspective of first-generation college students because it portrayed Kitatoi as an agentic individual who had the capacity to push against a system that failed to prepare her (as an adolescent) and pushed her out of college (incident of dismissal). Likewise, this study helps build theory of disciplinary role identity development for first-generation college students who are nontraditional students.

6.2 Juxtaposing Study 2 and Study 3

Study 2 provided connections for how personal agency supported the development of disciplinary role identities, how mathematics identity supported a physics identity, how seeing oneself as a math and physics type of person supported the development of an engineering identity. In Study 2, I used a sample of first-generation college students who enrolled in college directly after graduating high school. The experiences both in- and out- of the classroom afforded to these first-generation college students supported the development of their disciplinary role identities (i.e., in the context of mathematics, physics, and engineering). Findings from Study 2 also confirmed that first-generation college students enter engineering with a disposition to make a difference in their world through engineering. Many of the students in Study 2, 39% of the sample, took advance mathematics courses (i.e., Calculus AB), and 85% of these students took some type of physics course in high school. These experiences, along with other disciplinary role identity shaping experiences, mostly likely supported their beliefs of seeing themselves as individuals that can do engineering. The connections found in Study 2 are considered general trends for first-generation college students, for both women and men, who enter engineering granting programs directly after graduating high school. Study 3 was a single case study of a different experience for first-generation college students; that is, those who have spent several years in community college, are older than "traditional-age students," and have additional life responsibilities (i.e., caring for children or holding full-time jobs) also known as nontraditional students. The relationships modeled in Study 2 held true to the experience of Kitatoi, albeit her path towards developing a mathematics and physics identities were layered with experiences that would not be common to students who enter college directly after graduating high school.

The first-generation college students, from both Study 2 and 3, enacted their personal agency in developing mathematics and physics identities to support pathways into engineering, albeit at different time sequences. Kitatoi, essentially restarted her pathway towards advanced mathematics courses as a community college student, while the sample of traditional age first-generation college students were on an educational pathway that had access to these types of opportunities. Similarly, for both samples of participants, having authored an identity as a mathematics type of person was instrumental towards their abilities to see themselves as physics type of people. In Study 2, authoring a mathematics identity had twice the estimate for authoring a physics identity than students' ability to enact their agency. In study 3, authoring a mathematics identity supported Kitatoi's interest in pursuing an engineering career however, her trajectory into engineering was still contested due to environmental factors (i.e., physics course sequence and lack of representation of women in physics). Kitatoi's ability to enact her agency and control events that affected her life lead her to move from community college one, to community college two for the sole purpose of taking the physics course series. Having authored an identity as a mathematics type of person, *alone*, was not enough to support her physics identity, Kitatoi needed to feel as though she had taken control of her environment by selecting a space that was less threatening (i.e., physics classes at community college two). Study 2 provided an understanding of how an engineering identity is developed through mathematics and physics, and as a result of the interest, recognition, and performance/competence beliefs students hold pertaining to engineering. While Kitatoi's narrative described how one's trajectory through engineering can disrupt beliefs about performing well in engineering and how recognition can both be denied and transmitted to a student. Likewise, Kitatoi's narrative described how an individuals' multiple identities, at times, can sit in tension with how a person acts on their environment and how the environment can act on that person. Acting on the environment and being acted on by the environment impacts students' recognition, performance/competence beliefs, and interest in engineering. When comparing both Study 1 and Study 2, I found that interest held the highest estimate onto students' engineering identity and Kitatoi's narrative described how she remained interested in the subject despite not performing at the level she intended and, at times, being denied recognition. Lastly, while Study 2 found that first-generation college students held a disposition to better the world through engineering, Kitatoi's narrative described how the process of becoming an engineer was going to better her life, her position in society and that of her children.

6.3 Practical Strategies for Flexing Students' Agentic Muscles for Engineering Educators and Practitioners

Structural and cultural changes are necessary and important to promote the success of marginalized groups like first-generation college students; however, rather than wait on change within the university system and more specifically within the culture of engineering, educators need to empower first-generation college students to recognize that they are capable, agentic individuals that can make changes in their life and world around them. This approach can support students in spite of the problematic nature of engineering.

In this section, I provide agentic strategies practitioners and educators can adopt in their interactions with first-generation college students. I believe programmatic efforts (i.e., understanding financial aid, navigating college, etc.) that currently support first-generation college students should shift towards a lens of empowerment. Napper and Rao's (2019) book *The Power of Agency* outlined a set of principles that allow individuals to enact their agency and construct a life of their own choosing. I outline broad principles in the sections that follow that can be converted into workshops or mini-lecture series for engineering educators seeking to support their first-generation college student population. In the following sections, I discuss the importance of four strategies: 1) fostering reflective capacities, 2) managing beliefs and reactions, and 3) positioning students as learners, that can nurture first-generation college students' agentic muscle.

Foster Reflective Capacities. I have established that first-generation college students are capable of reflecting on their actions and regulating towards the pursuit of their goals (i.e., making a difference in the world and seeing oneself as a STEM type of person). It is also likely that new environments often challenge first-generation college students' capacities to act on the world; therefore, it's important that educators remind their students that they are individuals who can self-organize, self-reflect, self-regulate, and are "not just reactive … shaped and shepherded by external events" (Bandura, 1999c, p. 2). Educators should encourage first-generation college students to be reflective of their experiences. Reflective practices can help students either build confidence and efficacy in the tasks they are engaging with because they are recalling prior accomplishments or prior practices that were successfully executed. Bandura (2018) declared, "unless people believe they can produce desired effects by their actions they have little incentive to act or to persevere in the face of difficulties" (p. 133). Scholars have affirmed that learning by reflecting on experience is a difficult task when practicing alone or without facilitation (Brockbank & McGill, 1998; Kember et al., 2000). Part of motivating students is reintroducing them to the fact that they are capable agents, inviting students to reflect on their achievements through reflective dialogue. The survey items, on the personal agency scale, developed for the construct of self-reflectiveness can serve as a self-diagnostic to understand how well students engage in reflective thinking or as a way to situate dialogue about reflection. Brockbank and McGill (1998) drawing from the work of Dewey, expressed that reflection on prior experiences is an essential process of learning with the understanding that students are reflecting from "genuine situation of experiences, genuine problem in a [particular] situation, and observations about the situation" (p. 24). Educators and practitioners can invite students to reflect on the achievement of a goal(s) by asking reflective questions such as, “Think about the time you were able to achieve a goal, what types of intentional steps did you take?” Additionally, students should also dissect the root causes of why goals were not achieved, suggested probing questions include, “Think of a time you were not able to achieve a goal, what intentional steps were missing? What factors in your environment stopped you from achieving your goal? After having identified intentional steps missing and environmental factors that stopped you from achieving your goal, what are some strategies you can implement in the future?” These questions can be applied in the classroom setting by offering students an opportunity to reflect on the outcome of a test, team project, or any major assignments. Likewise, these questions can be presented in programmatic events outside of the classroom setting, perhaps as part of a larger university initiative focused on student success or through established programs such as Mathematics Engineering Science Achievement (MESA) program, Minority in Engineering Programs (MEP)-like programs, or First Forward program from the Center for First-generation Student Success. To support students who work long hours or have additional commitments outside of university coursework, institutions or colleges can consider using alternative methods of delivery such as online modules or creating an online first-generation college student community group. While reflection is not a new concept, the reflective questions I have proposed should be proposed as a tool towards strengthening first-generation college students’ agentic capabilities.

Managing Beliefs and Reactions. The principle of managing beliefs and reactions by Napper and Rao (2019) is a useful strategy for first-generation college students that feel the weight of environmental factors and feel as though they do not have agency to act against environmental constraints. It is not uncommon that low performance on an exam or in a course, as well as a generally negative environment created by others’ limiting beliefs, can undermine a students’ sense of agency. Students can hold positive and uplifting beliefs about themselves and their capabilities, enabling agency, but they can also be stuck in self-defeating and negative thoughts. Napper and Rao (2019) acknowledged that “… we simply have a hard time stepping outside of our beliefs to question them” (p. 179). The ability to manage one’s beliefs, whether they are self-generated or externally imposed through interaction with individuals in the environment, constitutes agency in action.

Recall Kitatoi's belief that "only smart people did physics" when she was faced with the circumstance of having to enroll in physics to transfer or her belief that "this is just the type of student that I am" as she struggled to obtain grades that were above average. In these situations, Kitatoi executed intentional action plans to ensure she would be a successful student in the physics courses and combat the negative thoughts of being an average student. These agentic strategies allowed her to persevere through her mathematics courses. Kitatoi's reaction to the experience emulated the agentic capability of acting on one's environment. The agentic strategy of managing beliefs and reactions comes with the caveat that first-generation college students' experiences should not be diminished or silenced rather, this strategy should be employed as a way to move forward despite negative environmental impacts. Educators and practitioners can help support the idea of acting and reacting agentically by drawing awareness of the limiting beliefs students fall victim to and providing strategies to counteract them. Helping first-generation college students manage their beliefs can be a simple as inviting them to step outside of their beliefs and *question* them (i.e., practicing self-awareness). A practical strategy that educators or practitioners could implement to foster a *positive agentic internal voice* include,

1) asking students to write down both positive and negative beliefs they currently hold about their capabilities,
2) ask students to write down their positive and negative beliefs about their current school environment, and
3) ask students to write down positive and negative beliefs about who they are (i.e., their multiple identities) in relation to their current school environment.

Having first-generation college students go through the exercise of honestly acknowledging their current beliefs can make them consciously aware of the belief system they currently hold. As Napper and Rao (2019) pointed out, individuals often have a difficult time stepping outside of our current ways of thinking; therefore, going through the exercise of listing one's current perceptions is the first step. After students participated in the exercise of consciously acknowledging their current positive and negative beliefs, the facilitator of this activity can then ask students, "identify where your positive and negative beliefs are coming from?" or ask, "how did you come to hold these set of beliefs?" Once students have identified their positive and negative beliefs and have identified how they came to view themselves and their environment around them in a particular way, the next step would be equipping students with practical strategies to control their negative beliefs and strengthen/grow their positive beliefs. A practical strategy students can use to strengthen or grow their current positive beliefs is using guided imagery to imagine oneself achieving a task or goal, with specific emphasis on the intentional action plans that can be taken. A practical strategy students can use to push away negative beliefs is to be aware and voice their current physical state. Anxiety and stress can cause students to believe they do not have control over their lives and is a breeding ground for negative beliefs to foster, thus acknowledging their current physical state can allow them to recognize the root cause of their current beliefs. This exercise can be done in a community group of first-generation college students either in person or virtually.

Positioning First-Generation College Students as Learners. First-generation college students will often receive messages that, as students who are the first in their families to attend college, they will inevitably lack knowledge, lack navigational skills, or lack capital. Thus, the college environment subtly, and possibly not so subtly, positions these students as victims of their life's circumstances as opposed to agentic individuals capable of controlling events that affect their lives. Reframing the implicit messages of, "*You don't know how to …*" to "*How can I…"* invites students to take control of their lives by actively choosing the position of learners and this approach can continue to foster their sense of agency and expand their knowledge and beliefs in their capabilities. Napper and Rao (2019) state that "positioning [oneself] as a learner requires *active questioning*" (p. 129, emphasis in original). Often first-generation college students state that they do not know the types of questions to ask or that "they don't know what they don't know." The mere act of providing a safe space where first-generation college students can be open to acknowledging they do not know which questions to ask can help position them as learners. During the first days of orientation, student affairs practitioners or those in charge of the incoming engineering cohort can make an acknowledgment that students should view their trajectory through engineering as a learning progression. Learning not only the engineering content knowledge but also *how* to actively question the structure of their environment so that they can agentically move forward. Once first-generation college students have a grasp on how their new environment is structured, they can then agentically position themselves as problem solvers (i.e., "How can I …").

Likewise, Carol Dweck's work on growth mindset can be a useful tool for first-generation college students to accept that failure is part of life, and failure offers opportunities from which to learn. A growth mindset involves the belief that one's abilities or intelligence are not fixed but can be developed over time while a fixed mindset leads students to believe that having abilities or intelligence are something you are born with (Yeager & Dweck, 2012). Students that internalize a fixed mindset think that tasks need to come naturally to them and they do not need to apply much effort; while students with a growth mindset view difficult tasks as opportunities to learn and grow (Dweck, 2010). The beliefs students hold about themselves matter, thus ensuring that first-generation college students are positioning themselves as capable of learning (i.e., growth mindset) can build confidence and agency. A practical strategy engineering educators can practice in their own classrooms include, acknowledging on the first day of class that the classroom culture supports a growth mindset approach. Instructors can present in one simple PowerPoint slide the difference between having a growth mindset versus a fixed mindset, this would give students the language to draw from when they find themselves struggling on an assignment. Also, instructors can deliver feedback to their students that promote the *processes, choices,* and *strategies* they used to solve a problem even if they arrived at an incorrect solution. Instructors can reintroduce the topic of growth mindset to the class after grades on a difficult assignment, probing students to believe they are capable of learning the material despite receiving low marks. University programs supporting first-generation college students can also make students aware of the difference between having growth and a fixed approach to their capabilities through programmatic efforts. Once students have the language to understand the difference between focusing on "smartness" versus focusing on effort they can then start to self-regulate by agentically deciding to view their learning progression as a process rather than an innate trait.

6.4 Practical Strategies for Enacting Engineering Agency for Engineering Educators

In Study 2, my modeled demonstrated that first-generation college students' capabilities of enacting their goals (i.e., personal agency) strongly supported their beliefs of using engineering as a tool towards making a difference in their community or world around them (i.e., engineering agency beliefs). In turn, students' engineering agency beliefs supported their engineering identity development more than having a mathematics and physics identity. Based on the findings of this model, it is important to provide tangible activities that allow first-generation college students to see themselves making a difference in their community or world around them.

A possible strategy that can be implemented is offering service-learning activities where students identify a community need and use the engineering design process and strategies to provide the community with an evidence-based decision that is meaningful to the community. Service-learning projects in engineering are not a new pedagogical concept; see (Jawaharlal, Fan, & Monemi, 2006; Oakes et al., 2002; Tsang, Van Haneghan, Johnson, Newman, & Van Eck, 2001). Therefore, I am not proposing a new practical strategy; instead, I am emphasizing how students engineering agency beliefs can be further developed when given the opportunity to enact this form of agency that is critical for first-generation college students' engineering identity development.

Additionally, service-learning projects should not be limited to the higher education space; instead, practitioners can also engage students at the K-12 level to enact critical agency in the context of mathematics, physics, and engineering. For example, in Turner's (2003) study, she used mathematics as the tool towards enacting change in her students' community. In the students' context, there were pervasive inequalities in the standardized metrics used to measure mathematics competencies and the challenges low income, urban schools faced. Her intention was to link student agency to ideas of empowerment and social justice, and thus creating critical and active participants in society through mathematics education. This approach placed mathematics in a context that allowed students to learn in ways that prepared them to explore, challenge, and take action on matters that affect their lives and communities (Turner & Varley, 2007). Acts of personal agency in their study included students' resistance of the label of "underperforming" by using data of test scores to support their act of resistance and using survey data to recognize the contributions of the immigrant members of their community as a response to criminalizing narratives portrayed by the media (Turner & Varley, 2007).

In recent years, many states have adopted educational standards called Next Generation Science Standards. These standards offer an opportunity to create learning activities that expose K-12 students to engineering design principles, incorporate math, science and technological skills, and promote engineering habits of mind, which are systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations (National Research Council, 2009, p. 152). The adoption of engineering practices and habits of mind in K-12 education offers an avenue towards creating activities that promote engineering agency beliefs and promote students' views of engineering as a tool towards enacting change in students' communities.

6.5 Limitations

The three studies presented in this dissertation do not come without limitations. I will describe the limitations by individual study. In Study 1, I used a large sample of students to conduct an EFA and CFA; however, before the data collection phase, I could have convened a small focus group of first-year engineering students to provide me with feedback on the revised items. The goal of the focus group would have been to ensure the language used in the survey items were simple and common across a diverse group of students, to determine if students conceptually distinguish the items into the hypothesized latent constructs. In Study 2, I was bounded to the battery of survey items that were asked in the CAREER survey. Given the opportunity to include a larger set of survey items, I would have included items pertaining to out-of-school experiences, specifically focused on formal activities, or activities at home (i.e., funds of knowledge). By adding a list of activities to select in the survey scale, I can then determine which activities supported first-generation college students' disciplinary role identities. In Study 3, I believe my participant would have benefited from having a sample, detailed journey map to help her understand the level of depth she could apply in her own depiction. While her narrative had rich descriptive events and reactions, the journey map she presented to me was oversimplified compared to her overall story. Additionally, while Kitatoi's story is still ongoing and while she came to see herself as a capable engineering student, her trajectory may take a different turn before she graduates from Research State University. Given ample time, it would have been best to continue following Kitatoi until degree completion to capture a holistic narrative of engineering identity development; for this dissertation, that was not possible. Likewise, given the opportunity to conduct another interview, I would have wanted to learn more about the types of engineering experiences (i.e., internships, research opportunities, etc.) Kitatoi is interested in obtaining.

6.6 Future Work

Future work, that seeks to use an asset based approach, can identify the experiences that supported first-generation college students' engineering identity development. For example, in Study 2, I found that 85% of students did not participate in a common out-of-school experience (i.e., Project Lead the Way) therefore, it would be worth identifying at a larger scale the types of out of school activities that support their engineering identity. Additionally, in Study 2, I found that first-generation college students cited their mother, father, and friends contributed to their choice of an engineering career path (55%, cited their mother; 56%, cited their father; 41% cited friend[s]). Future work can explore the effects first-generation college students' social networks have on their choices of pursuing an engineering identity and if these social networks influence their engineering agency beliefs. Likewise, a small percentage of students reported their mathematics, physics, chemistry, biology teachers had an impact in their choice of pursuing an engineering career, future work can explore how students who will be the first in their families to attend college are denied or afforded recognition as STEM-type of people. This correlations begs the question of, Are mathematics, physics, chemistry, biology high school teachers systematically denying recognition to students who do not have college educated parents? Answering this question can provide additional ways to support first-generation college students' pathway into engineering.

Future work can also explore the reasons that lead first-generation college students to hold engineering agency beliefs, how the belief of making a difference in the world developed, and if this belief remained consistent over time (i.e., as students pass through the engineering curriculum). In exploring first-generation college students engineering agency beliefs, an experimental study can be conducted that examines if students who were exposed to activities congruent with their desired to make a difference in the world were more likely to graduate, feel a sense of belonging to the engineering community of practice, or have a more solidified engineering identity, compared to the control group. Another experimental study, with first-generation college students, can be conducted to evaluate the effectiveness of some of the proposed practical strategies.

Research from this dissertation study can also be used to develop a robust workshop series or online workshops series that aims to strengthen students' personal agency and test the effectiveness of these workshops on first-generation college students' perseverance, agentic abilities to implement strategies for success, and overall disposition towards completing their engineering degree. First-generation college students that participate in the workshop series can be evaluated against other first-generation college students who did not participate in the workshops (i.e., control group). The purpose of comparing the experimental group with the control group would be to determine if a positive change is developing or if the experimental group are more likely to default to a positive agentic voice when faced with adversity.

6.7 Concluding Remarks

Enacting agency is a capability that every individual holds. When first-generation college students are positioned in a deficit lens, their agency is being denied and suppressed. Focusing on first-generation college students' agency and how it is enacted in the various environments (i.e., environments that are imposed, selected, and constructed) can open new possibilities for understanding these students' trajectory and capabilities for success.

APPENDIX A. SURVEY CODEBOOK USED IN STUDY 1 FOR PILOT SURVEY AND CAREER SURVEY

Personal Agency used in the *Pilot Survey* administered in Spring 2017

Q1. To what extent do you agree or disagree with the following statements:

Q1a = I have goals in mind before I start something. (Int)
Q1b = I monitor my actions to achieve my goals. (Fore)
Q1c = I think about my experiences so I can learn from them. (Ref)
Q1d = I consider many courses of action to reach my goals. (Fore)
Q1e = I set goals that are achievable. (Int)
Q1f = I imagine opportunities that might be open to me in the next five years. (Fore)
Q1g = I keep myself motivated to reach my goals. (Reac)
Q1h* = I complete tasks without knowing the end goal. (Int)
Q1i = My plans become actions. (Int)
Q1j = I make intentional decisions about how to accomplish tasks. (Int)
Q1k = I reflect on the way others do something to think of a better way of doing it. (Ref)
Q1l = I monitor my plans to achieve my goals. (Reac)
Q1m = I weigh the pros and cons before executing an action. (Fore)
Q1n = I adjust my plans when necessary. (Reac)
Q1o = I think about my past performance to guide my future actions. (Ref)
Q1p = I set goals to accomplish assignments. (Int)
Q1q = I actively keep myself on track to complete my plans. (Reac)
Q1r* = I make commitments without having a purpose in mind.
Q1s = I reflect on my actions to see if I could have made improvements. (Ref)
Q1t = I consider consequences when making plans. (Fore)
Q1u = I think about my experiences to improve on my next performance. (Ref)
Q1v = I imagine possible future events in my life. (Fore)
Q1w* = I don’t think over a situation before acting on it (Fore)
Q1x = I think over what I have done to consider alternative ways of doing it. (Ref)
Q1y = I imagine my future in terms of the next five several years. (Fore)
Q1z = I have a specific purpose when I make a commitment. (Int)

VALUES: 0 through 6 (rating scale); 0 = “strongly disagree”, 6 = “strongly agree”, " "= missing
Note. Items with * are reverse coded

Personal Agency used in the *CAREER Survey* administered in Fall 2017

Q8. To what extent do you agree or disagree with the following statements:

Q8a = I make intentional decisions about how to accomplish my plans (Int)
Q8b = I monitor my actions to achieve my goals. (Reac)
Q8c = I think about my experiences so I can learn from them. (Ref)
Q8d = I consider many courses of action to reach my plans. (Fore)
Q8e = I set goals to accomplish assignments. (Int)

Q8f = I keep myself motivated to reach my goals. (Reac)
Q8g = My plans become actions. (Int)
Q8h = I reflect on the way others do something to think of a better way of doing it. (Ref)
Q8i = I weigh the pros and cons before executing an action. (Fore)
Q8j = I actively keep myself on track to complete my plans. (Reac)
Q8k = I have a specific purpose when I make a commitment. (Int)
Q8l = I reflect on my actions to see if I could have made improvements. (Ref)
Q8m = I anticipate potential consequences when making plans. (Fore)
Q8n = I think about my experiences to improve on my next performance. (Ref)
Q8o = I think over what I have done to consider alternative ways of doing it. (Ref)

VALUES: 0 through 6 (rating scale); 0 = “strongly disagree”, 6 = “strongly agree”, " "= missing

APPENDIX B. R CODE FOR STUDY 1

R code for Study 1 can be found in the next page.

R Code Study 1

```
library(car)
library(nFactors)
library(lm.beta)
library(psy) #has cronbach
library(lavaan)
library(GPArotation)
library(semPlot)
library(semTools)
library(ggplot2)
library(nonnest2)
library(MVN)
library(Amelia)
library(xtable)

#PILOT DATASET Collected Spring 2017
 agency <- read.csv(file="/Users/dverdin/Documents/Research
Projects/PRELIM/Agency_Pilot_RAWDATA.csv",
                   header=TRUE, sep=",")

#recoding the reserve coded items
agency$Q1h <- 6-agency$Q1h
agency$Q1r <- 6-agency$Q1r
agency$Q1w <- 6-agency$Q1w

# Descriptive Statistics.
describe(agency[,c(2:8, 10:18, 20:23, 25:27)])

##     vars   n mean   sd median trimmed  mad min max range  skew kurtosis
## Q1a    1 113 5.80 1.01    6.0    5.90 1.48   2   7     5 -0.77     0.71
## Q1b    2 113 5.47 1.04    5.0    5.48 1.48   3   7     4 -0.11    -0.83
## Q1c    3 113 5.75 1.05    6.0    5.85 1.48   3   7     4 -0.56    -0.36
## Q1d    4 113 5.56 1.13    6.0    5.63 1.48   2   7     5 -0.61     0.18
## Q1e    5 112 5.33 1.25    5.0    5.39 1.48   1   7     6 -0.53     0.06
## Q1f    6 113 5.41 1.31    6.0    5.54 1.48   2   7     5 -0.68    -0.21
## Q1g    7 112 5.29 1.28    5.5    5.37 0.74   2   7     5 -0.36    -0.85
## Q1i    8 113 4.98 1.21    5.0    5.00 1.48   2   7     5 -0.06    -0.59
## Q1j    9 112 5.54 0.97    6.0    5.58 1.48   3   7     4 -0.34    -0.21
## Q1k   10 113 5.63 0.96    6.0    5.67 1.48   3   7     4 -0.30    -0.60
## Q1l   11 113 5.20 1.20    5.0    5.24 1.48   2   7     5 -0.24    -0.44
## Q1m   12 113 5.31 1.32    5.0    5.41 1.48   1   7     6 -0.58     0.01
## Q1n   13 112 5.72 0.99    6.0    5.79 1.48   3   7     4 -0.32    -0.71
## Q1o   14 112 5.71 0.98    6.0    5.79 1.48   3   7     4 -0.49    -0.31
## Q1p   15 113 5.54 1.20    6.0    5.66 1.48   2   7     5 -0.84     0.48
## Q1q   16 113 5.13 1.39    5.0    5.22 1.48   1   7     6 -0.52    -0.38
## Q1s   17 112 5.34 1.14    5.0    5.40 1.48   2   7     5 -0.43    -0.25
## Q1t   18 113 5.48 1.23    6.0    5.58 1.48   1   7     6 -0.81     0.69
## Q1u   19 113 5.53 1.04    6.0    5.58 1.48   3   7     4 -0.37    -0.40
```

```
## Q1v   20 113 5.75 1.13    6.0    5.88 1.48   2   7     5 -0.80     0.28
## Q1x   21 113 5.32 1.17    5.0    5.38 1.48   1   7     6 -0.73     0.82
## Q1y   22 113 4.92 1.45    5.0    4.99 1.48   1   7     6 -0.38    -0.39
## Q1z   23 112 5.23 1.04    5.0    5.20 1.48   3   7     4  0.06    -0.83
##       se
## Q1a 0.10
## Q1b 0.10
## Q1c 0.10
## Q1d 0.11
## Q1e 0.12
## Q1f 0.12
## Q1g 0.12
## Q1i 0.11
## Q1j 0.09
## Q1k 0.09
## Q1l 0.11
## Q1m 0.12
## Q1n 0.09
## Q1o 0.09
## Q1p 0.11
## Q1q 0.13
## Q1s 0.11
## Q1t 0.12
## Q1u 0.10
## Q1v 0.11
## Q1x 0.11
## Q1y 0.14
## Q1z 0.10

mahal <- mahalanobis(agency[,c(2:8, 10:18, 20:23, 25:27)],
                     colMeans(agency[,c(2:8, 10:18, 20:23, 25:27)],
                              na.rm = TRUE),
                     cov(agency[,c(2:8, 10:18, 20:23, 25:27)],
                         use="pairwise.complete.obs"))
summary(mahal)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##    3.57   15.56   19.33   22.27   26.62   66.88       6

cutoff <- qchisq(.999, ncol(agency[,c(2:8, 10:18, 20:23, 25:27)])) #using p<
0.001

summary(mahal < cutoff)

##    Mode   FALSE    TRUE    NA's
## logical       3     104       6

#### need to delete the FALSE variables (cases removed 3)
#after removing reserve coded variables

agency_noout <- agency[ mahal < cutoff , ] ##creates a new dataset w/ NO
```

```
outliers
agency_noout <- as.data.frame(agency_noout)

####08/20/2018#####
#I'm going to remove the negatively worded items from the analysis
##removed were Q1h, Q1r, Q1w

attach(agency_noout)

agencyQ1 <- as.data.frame(cbind(Q1a, Q1b, Q1c, Q1d, Q1e, Q1f, Q1g, Q1i, Q1j,
Q1k, Q1l,
                                Q1m, Q1n, Q1o, Q1p, Q1q, Q1s, Q1t, Q1u, Q1v,
                                Q1x, Q1y, Q1z))

detach(agency_noout)

describe(agencyQ1)

##     vars   n mean   sd median trimmed  mad min max range  skew kurtosis
## Q1a    1 104 5.77 1.03      6    5.87 1.48   2   7     5 -0.76     0.64
## Q1b    2 104 5.43 1.05      5    5.44 1.48   3   7     4 -0.07    -0.87
## Q1c    3 104 5.71 1.04      6    5.80 1.48   3   7     4 -0.54    -0.31
## Q1d    4 104 5.56 1.13      6    5.63 1.48   2   7     5 -0.64     0.27
## Q1e    5 104 5.34 1.28      5    5.40 1.48   1   7     6 -0.53     0.01
## Q1f    6 104 5.45 1.28      6    5.58 1.48   2   7     5 -0.68    -0.24
## Q1g    7 104 5.31 1.28      6    5.39 1.48   2   7     5 -0.39    -0.82
## Q1i    8 104 5.06 1.18      5    5.06 1.48   2   7     5 -0.01    -0.70
## Q1j    9 104 5.53 0.94      6    5.56 1.48   3   7     4 -0.25    -0.32
## Q1k   10 104 5.62 0.95      6    5.65 1.48   3   7     4 -0.33    -0.54
## Q1l   11 104 5.23 1.18      5    5.25 1.48   2   7     5 -0.20    -0.34
## Q1m   12 104 5.36 1.21      5    5.42 1.48   2   7     5 -0.34    -0.63
## Q1n   13 104 5.67 0.97      6    5.73 1.48   3   7     4 -0.27    -0.66
## Q1o   14 104 5.69 1.00      6    5.76 1.48   3   7     4 -0.47    -0.37
## Q1p   15 104 5.55 1.21      6    5.67 1.48   2   7     5 -0.84     0.46
## Q1q   16 104 5.18 1.31      5    5.25 1.48   2   7     5 -0.34    -0.75
## Q1s   17 104 5.42 1.10      5    5.48 1.48   2   7     5 -0.45    -0.09
## Q1t   18 104 5.43 1.24      6    5.54 1.48   1   7     6 -0.79     0.59
## Q1u   19 104 5.52 1.00      6    5.56 1.48   3   7     4 -0.31    -0.40
## Q1v   20 104 5.74 1.12      6    5.87 1.48   2   7     5 -0.83     0.44
## Q1x   21 104 5.35 1.11      5    5.39 1.48   2   7     5 -0.45    -0.19
## Q1y   22 104 4.94 1.44      5    5.01 1.48   1   7     6 -0.42    -0.32
## Q1z   23 104 5.24 1.05      5    5.21 1.48   3   7     4  0.02    -0.85
##       se
## Q1a 0.10
## Q1b 0.10
## Q1c 0.10
## Q1d 0.11
## Q1e 0.13
## Q1f 0.13
## Q1g 0.13
```

```
## Q1i 0.12
## Q1j 0.09
## Q1k 0.09
## Q1l 0.12
## Q1m 0.12
## Q1n 0.10
## Q1o 0.10
## Q1p 0.12
## Q1q 0.13
## Q1s 0.11
## Q1t 0.12
## Q1u 0.10
## Q1v 0.11
## Q1x 0.11
## Q1y 0.14
## Q1z 0.10

corstars <- function(x){
  require(Hmisc)
  x <- as.matrix(x)
  R <- rcorr(x)$r
  p <- rcorr(x)$P

  ## define notions for significance levels; spacing is important.
  mystars <- ifelse(p < .001, "***", ifelse(p < .01, "** ", ifelse(p < .05,
"* ", " ")))

  ## trunctuate the matrix that holds the correlations to two decimal
  R <- format(round(cbind(rep(-1.11, ncol(x)), R), 2))[,-1]

  ## build a new matrix that includes the correlations with their apropriate
stars
  Rnew <- matrix(paste(R, mystars, sep=""), ncol=ncol(x))
  diag(Rnew) <- paste(diag(R), " ", sep="")
  rownames(Rnew) <- colnames(x)
  colnames(Rnew) <- paste(colnames(x), "", sep="")

  ## remove upper triangle
  Rnew <- as.matrix(Rnew)
  Rnew[upper.tri(Rnew, diag = TRUE)] <- ""
  Rnew <- as.data.frame(Rnew)

  ## remove last column and return the matrix (which is now a data frame)
  Rnew <- cbind(Rnew[1:length(Rnew)-1])
  return(Rnew)
}

corstars(agencyQ1)
```

```
##           Q1a      Q1b      Q1c      Q1d      Q1e      Q1f      Q1g
## Q1a
## Q1b  0.69***
## Q1c  0.51***  0.64***
## Q1d  0.45***  0.54***  0.64***
## Q1e  0.51***  0.47***  0.40***  0.59***
## Q1f  0.42***  0.37***  0.35***  0.35***  0.42***
## Q1g  0.46***  0.54***  0.50***  0.51***  0.52***  0.52***
## Q1i  0.48***  0.65***  0.59***  0.51***  0.54***  0.47***  0.57***
## Q1j  0.50***  0.58***  0.66***  0.55***  0.50***  0.43***  0.44***
## Q1k  0.39***  0.44***  0.62***  0.47***  0.38***  0.28**   0.31**
## Q1l  0.52***  0.70***  0.54***  0.57***  0.50***  0.35***  0.57***
## Q1m  0.52***  0.55***  0.40***  0.46***  0.37***  0.32**   0.42***
## Q1n  0.42***  0.51***  0.39***  0.48***  0.40***    0.18   0.29**
## Q1o  0.43***  0.55***  0.58***  0.43***  0.33***  0.30**   0.41***
## Q1p  0.44***  0.61***  0.51***  0.41***  0.32***   0.23*   0.45***
## Q1q  0.45***  0.56***  0.38***  0.43***  0.38***  0.30**   0.60***
## Q1s  0.44***  0.45***  0.59***  0.52***  0.43***  0.28**   0.38***
## Q1t  0.50***  0.49***  0.53***  0.52***  0.47***  0.29**   0.48***
## Q1u  0.42***  0.50***  0.59***  0.49***  0.41***   0.23*   0.40***
## Q1v  0.40***  0.30**   0.41***  0.28**   0.28**   0.60***   0.20*
## Q1x  0.41***  0.39***  0.61***  0.45***  0.36***  0.32***  0.36***
## Q1y  0.40***   0.23*    0.24*    0.25*   0.35***  0.59***  0.26**
## Q1z  0.60***  0.54***  0.42***  0.50***  0.52***  0.41***  0.43***
##           Q1i      Q1j      Q1k      Q1l      Q1m      Q1n      Q1o
## Q1a
## Q1b
## Q1c
## Q1d
## Q1e
## Q1f
## Q1g
## Q1i
## Q1j  0.70***
## Q1k  0.53***  0.63***
## Q1l  0.57***  0.59***  0.45***
## Q1m  0.49***  0.44***  0.29**   0.65***
## Q1n  0.44***  0.35***  0.37***  0.53***  0.49***
## Q1o  0.43***  0.38***  0.41***  0.42***  0.40***  0.52***
## Q1p  0.49***  0.39***  0.33***  0.54***  0.32***  0.35***  0.45***
## Q1q  0.56***  0.42***  0.32***  0.64***  0.58***  0.48***  0.37***
## Q1s  0.55***  0.55***  0.52***  0.46***  0.41***  0.31**   0.46***
## Q1t  0.54***  0.51***  0.43***  0.53***  0.66***  0.42***  0.40***
## Q1u  0.55***  0.45***  0.53***  0.50***  0.46***  0.49***  0.61***
## Q1v  0.37***  0.40***  0.42***  0.34***  0.25**   0.30**   0.33***
## Q1x  0.58***  0.53***  0.62***  0.39***  0.36***  0.33***  0.43***
## Q1y  0.34***   0.23*    0.22*    0.24*    0.23*    0.22*    0.20*
## Q1z  0.58***  0.48***  0.44***  0.50***  0.43***  0.47***  0.30**
##           Q1p      Q1q      Q1s      Q1t      Q1u      Q1v      Q1x
## Q1a
```

```
## Q1b
## Q1c
## Q1d
## Q1e
## Q1f
## Q1g
## Q1i
## Q1j
## Q1k
## Q1l
## Q1m
## Q1n
## Q1o
## Q1p
## Q1q  0.63***
## Q1s  0.35***  0.34***
## Q1t  0.34***  0.44***  0.61***
## Q1u  0.49***  0.41***  0.61***  0.55***
## Q1v   0.23*    0.24*   0.30**   0.30**     0.17
## Q1x  0.30**   0.32**   0.65***  0.61***  0.52***  0.48***
## Q1y    0.13    0.21*    0.20*     0.12   0.30**   0.43***  0.31**
## Q1z  0.42***  0.49***  0.46***  0.50***  0.54***  0.27**   0.50***
##          Q1y
## Q1a
## Q1b
## Q1c
## Q1d
## Q1e
## Q1f
## Q1g
## Q1i
## Q1j
## Q1k
## Q1l
## Q1m
## Q1n
## Q1o
## Q1p
## Q1q
## Q1s
## Q1t
## Q1u
## Q1v
## Q1x
## Q1y
## Q1z  0.44***
```

After removing 3 outliers using mahanobis distance, I looked at the correlation matrix again, Q1y, Q1v, Q1f needed to be removed due to not correlating with other variables. NOTE: I have already removed the reverse coded items before running the mahalanobis distnace, I thought these items just didn't work well in general.

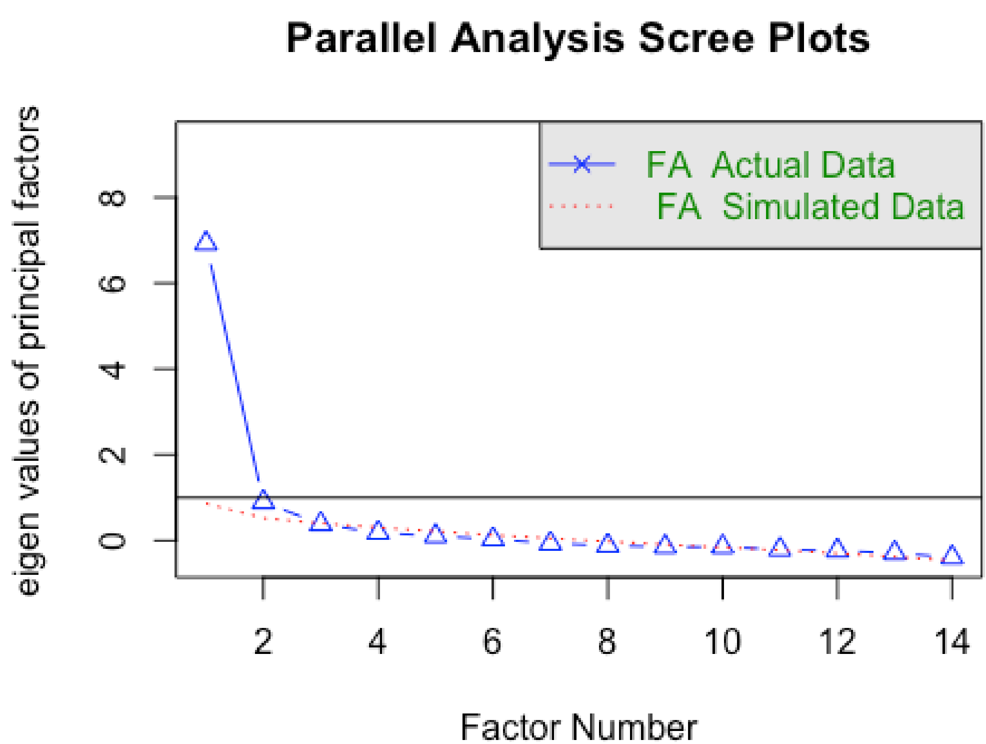
```
attach(agency_noout)

agencyQ1.2 <- as.data.frame(cbind(Q1a, Q1b, Q1c, Q1d, Q1e, Q1g, Q1i, Q1j,
Q1k, Q1l,
                                Q1m, Q1n, Q1o, Q1p, Q1q, Q1s, Q1t, Q1u,
                                Q1x, Q1z))

detach(agency_noout)

corstars(agencyQ1.2)

##          Q1a      Q1b      Q1c      Q1d      Q1e      Q1g      Q1i
## Q1a
## Q1b  0.69***
## Q1c  0.51***  0.64***
## Q1d  0.45***  0.54***  0.64***
## Q1e  0.51***  0.47***  0.40***  0.59***
## Q1g  0.46***  0.54***  0.50***  0.51***  0.52***
## Q1i  0.48***  0.65***  0.59***  0.51***  0.54***  0.57***
## Q1j  0.50***  0.58***  0.66***  0.55***  0.50***  0.44***  0.70***
## Q1k  0.39***  0.44***  0.62***  0.47***  0.38***  0.31**   0.53***
## Q1l  0.52***  0.70***  0.54***  0.57***  0.50***  0.57***  0.57***
## Q1m  0.52***  0.55***  0.40***  0.46***  0.37***  0.42***  0.49***
## Q1n  0.42***  0.51***  0.39***  0.48***  0.40***  0.29**   0.44***
## Q1o  0.43***  0.55***  0.58***  0.43***  0.33***  0.41***  0.43***
## Q1p  0.44***  0.61***  0.51***  0.41***  0.32***  0.45***  0.49***
## Q1q  0.45***  0.56***  0.38***  0.43***  0.38***  0.60***  0.56***
## Q1s  0.44***  0.45***  0.59***  0.52***  0.43***  0.38***  0.55***
## Q1t  0.50***  0.49***  0.53***  0.52***  0.47***  0.48***  0.54***
## Q1u  0.42***  0.50***  0.59***  0.49***  0.41***  0.40***  0.55***
## Q1x  0.41***  0.39***  0.61***  0.45***  0.36***  0.36***  0.58***
## Q1z  0.60***  0.54***  0.42***  0.50***  0.52***  0.43***  0.58***
##          Q1j      Q1k      Q1l      Q1m      Q1n      Q1o      Q1p
## Q1a
## Q1b
## Q1c
## Q1d
## Q1e
## Q1g
## Q1i
## Q1j
## Q1k  0.63***
## Q1l  0.59***  0.45***
## Q1m  0.44***  0.29**   0.65***
## Q1n  0.35***  0.37***  0.53***  0.49***
## Q1o  0.38***  0.41***  0.42***  0.40***  0.52***
## Q1p  0.39***  0.33***  0.54***  0.32***  0.35***  0.45***
```

```
## Q1q  0.42***  0.32***  0.64***  0.58***  0.48***  0.37***  0.63***
## Q1s  0.55***  0.52***  0.46***  0.41***  0.31**   0.46***  0.35***
## Q1t  0.51***  0.43***  0.53***  0.66***  0.42***  0.40***  0.34***
## Q1u  0.45***  0.53***  0.50***  0.46***  0.49***  0.61***  0.49***
## Q1x  0.53***  0.62***  0.39***  0.36***  0.33***  0.43***  0.30**
## Q1z  0.48***  0.44***  0.50***  0.43***  0.47***  0.30**   0.42***
##          Q1q      Q1s      Q1t      Q1u      Q1x
## Q1a
## Q1b
## Q1c
## Q1d
## Q1e
## Q1g
## Q1i
## Q1j
## Q1k
## Q1l
## Q1m
## Q1n
## Q1o
## Q1p
## Q1q
## Q1s  0.34***
## Q1t  0.44***  0.61***
## Q1u  0.41***  0.61***  0.55***
## Q1x  0.32**   0.65***  0.61***  0.52***
## Q1z  0.49***  0.46***  0.50***  0.54***  0.50***
```

Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (Kaiser, 1970), a statistic that represents the ratio of the squared correlation between variables to the squared partial correlation between variables using a range from 0 to 1.

```
#Run this function
kmo <- function(x)
{
  x <- subset(x, complete.cases(x)) # Omit missing values
  r <- cor(x) # Correlation matrix
  r2 <- r^2 # Squared correlation coefficients
  i <- solve(r) # Inverse matrix of correlation matrix
  d <- diag(i) # Diagonal elements of inverse matrix
  p2 <- (-i/sqrt(outer(d, d)))^2 # Squared partial correlation coefficients
  diag(r2) <- diag(p2) <- 0 # Delete diagonal elements
  KMO <- sum(r2)/(sum(r2)+sum(p2))
  MSA <- colSums(r2)/(colSums(r2)+colSums(p2))
  return(list(KMO=KMO, MSA=MSA))
}

#Run the test
kmo(agencyQ1.2)
```

```
## $KMO
## [1] 0.9112387
##
## $MSA
##       Q1a       Q1b       Q1c       Q1d       Q1e       Q1g       Q1i
## 0.9070677 0.9233856 0.9228152 0.9350830 0.9210805 0.8828709 0.9224808
##       Q1j       Q1k       Q1l       Q1m       Q1n       Q1o       Q1p
## 0.9271633 0.9340622 0.9260293 0.8582487 0.8926021 0.8952628 0.8700116
##       Q1q       Q1s       Q1t       Q1u       Q1x       Q1z
## 0.8690957 0.9456716 0.9229190 0.9166084 0.9087981 0.9179741

attach(agency_noout)

agencyQ1.2 <- as.data.frame(cbind(Q1a, Q1b, Q1c, Q1g, Q1j, Q1k,
                                Q1m, Q1p, Q1q, Q1s, Q1t, Q1u,
                                Q1x, Q1l))

detach(agency_noout)
# Scree plot.done on 05/16/2017
covMatrix <- cov(agencyQ1.2, use = "pairwise.complete.obs")

pa_agency <- fa.parallel(covMatrix, n.obs = 110, fa="fa", fm="minres",
            main="Parallel Analysis Scree Plots",
            n.iter=100, quant=.95)
```



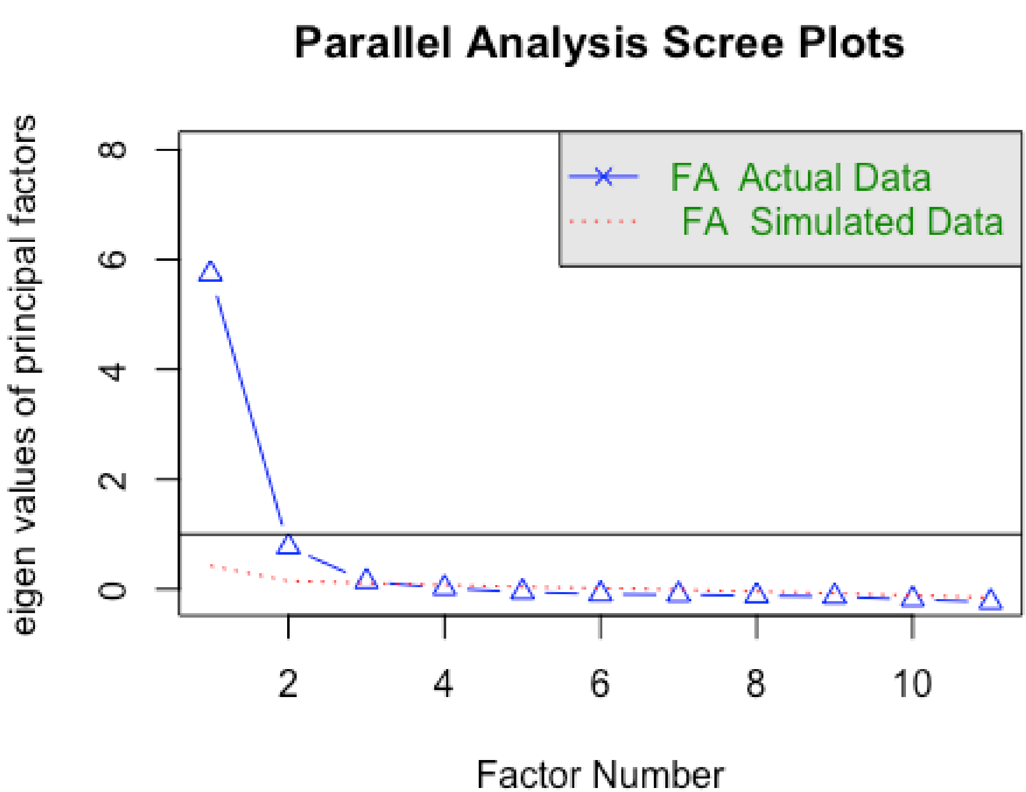
```
## Parallel analysis suggests that the number of factors =  2  and the number
of components =  NA
```

```r
fit_fa <- fac(covMatrix, nfactors=2, n.obs = 110,
              rotate = "promax", fm="minres",
                    residuals=TRUE, scores=TRUE)
print(fit_fa, digits=2, sort=TRUE)
```

```
## Factor Analysis using method =  minres
## Call: fac(r = covMatrix, nfactors = 2, n.obs = 110, rotate = "promax",
##     scores = TRUE, residuals = TRUE, fm = "minres")
## Standardized loadings (pattern matrix) based upon correlation matrix
##     item   MR1   MR2   h2   u2 com
## Q1q    9  0.95 -0.22 0.65 0.35 1.1
## Q1l   14  0.80  0.04 0.70 0.30 1.0
## Q1b    2  0.76  0.09 0.69 0.31 1.0
## Q1p    8  0.69 -0.02 0.46 0.54 1.0
## Q1g    4  0.66  0.03 0.47 0.53 1.0
## Q1m    7  0.65  0.07 0.49 0.51 1.0
## Q1a    1  0.54  0.20 0.48 0.52 1.3
## Q1x   13 -0.19  0.93 0.65 0.35 1.1
## Q1s   10 -0.04  0.81 0.61 0.39 1.0
## Q1k    6 -0.09  0.80 0.55 0.45 1.0
## Q1c    3  0.17  0.68 0.66 0.34 1.1
## Q1j    5  0.23  0.58 0.57 0.43 1.3
## Q1u   12  0.20  0.56 0.51 0.49 1.3
## Q1t   11  0.27  0.52 0.55 0.45 1.5
##
##                        MR1  MR2
## SS loadings           4.18 3.84
## Proportion Var        0.30 0.27
## Cumulative Var        0.30 0.57
## Proportion Explained  0.52 0.48
## Cumulative Proportion 0.52 1.00
##
##  With factor correlations of
##      MR1  MR2
## MR1 1.00 0.71
## MR2 0.71 1.00
##
## Mean item complexity =  1.1
## Test of the hypothesis that 2 factors are sufficient.
##
## The degrees of freedom for the null model are  91  and the objective
function was  9.27 with Chi Square of  959.66
## The degrees of freedom for the model are 64  and the objective function
was  1.32
##
## The root mean square of the residuals (RMSR) is  0.05
## The df corrected root mean square of the residuals is  0.06
```

```
##
## The harmonic number of observations is  110 with the empirical chi square
53.1  with prob <  0.83
## The total number of observations was  110  with Likelihood Chi Square =
134.52  with prob <  6.2e-07
##
## Tucker Lewis Index of factoring reliability =  0.883
## RMSEA index =  0.107  and the 90 % confidence intervals are  0.077 0.124
## BIC =  -166.31
## Fit based upon off diagonal values = 0.99
## Measures of factor score adequacy
##                                                    MR1  MR2
## Correlation of (regression) scores with factors   0.96 0.95
## Multiple R square of scores with factors          0.92 0.91
## Minimum correlation of possible factor scores     0.84 0.82

####LARGE SCALE DATASET Collected Fall 2017

load("~/Documents/Research
Projects/CAREER/Datasets/V2_20180625_CAREER_imputed.RData")

##created parented variable
career_imp$Q34a <- recode(career_imp$Q34a, "6=0")
career_imp$Q34b <- recode(career_imp$Q34b, "6=0")

career_imp$parented <- ifelse(career_imp$Q34a <=3 & career_imp$Q34b <=3, 1,
0)
table(career_imp$parented, useNA = 'always')

##
##    0    1 <NA>
## 2040  821  850

#0      1   <NA>
#2040  821  850

##this line gives me a dataset with students who marked NA for parents level
of education
na_study1 <- career_imp[is.na(career_imp$parented),]

mahal <- mahalanobis(na_study1[,c(118:132)],
                     colMeans(na_study1[,c(118:132)],
                              na.rm = TRUE),
                     cov(na_study1[,c(118:132)],
                         use ="pairwise.complete.obs"))
summary(mahal)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##  0.6893  6.4359 10.0277 14.0706 17.4602 84.6999     375
```

```r
cutoff <- qchisq(.999, ncol(na_study1[,c(118:132)])) #using p< 0.001

summary(mahal < cutoff) #### delete the FALSE variables (cases removed 34)

##    Mode   FALSE    TRUE    NA's
## logical      34     441     375

na_noout_study1 <- na_study1[ mahal < cutoff , ] ##new dataset w/ NO outliers
na_noout_study1 <- as.data.frame(na_noout_study1)

attach(na_noout_study1)

agencyQ1.3 <- as.data.frame(cbind(Q8b, Q8d, Q8f, Q8e,
                                  Q8g, Q8i, Q8j, Q8l,
                                  Q8m, Q8n, Q8o))

detach(na_noout_study1)

covMatrixv2 <- cov(agencyQ1.3, use = "pairwise.complete.obs")

pa_agencyv2 <- fa.parallel(covMatrixv2, n.obs = 816, fa="fa",
                           fm="minres",
                           main="Parallel Analysis Scree Plots",
                           n.iter=100, quant=.95)
```



```
## Parallel analysis suggests that the number of factors =  3  and the number
of components =  NA
```

```r
fit_v2 <- fac(covMatrixv2, nfactors=2, n.obs = 816, rotate = "promax",
              fm="minres",
              residuals=TRUE, scores=TRUE)
print(fit_v2, digits=2, sort=TRUE)
```

```
## Factor Analysis using method =  minres
## Call: fac(r = covMatrixv2, nfactors = 2, n.obs = 816, rotate = "promax",
##     scores = TRUE, residuals = TRUE, fm = "minres")
## Standardized loadings (pattern matrix) based upon correlation matrix
##     item   MR1   MR2   h2   u2 com
## Q8o   11  0.85 -0.04 0.67 0.33 1.0
## Q8n   10  0.83  0.00 0.69 0.31 1.0
## Q8i    6  0.79 -0.03 0.59 0.41 1.0
## Q8m    9  0.76 -0.01 0.56 0.44 1.0
## Q8l    8  0.67  0.13 0.58 0.42 1.1
## Q8d    2  0.61  0.15 0.53 0.47 1.1
## Q8f    3 -0.11  0.86 0.62 0.38 1.0
## Q8g    5  0.02  0.75 0.59 0.41 1.0
## Q8e    4  0.08  0.74 0.64 0.36 1.0
## Q8j    7  0.07  0.73 0.61 0.39 1.0
## Q8b    1  0.12  0.71 0.64 0.36 1.1
##
##                        MR1  MR2
## SS loadings           3.61 3.09
## Proportion Var        0.33 0.28
## Cumulative Var        0.33 0.61
## Proportion Explained  0.54 0.46
## Cumulative Proportion 0.54 1.00
##
##  With factor correlations of
##     MR1 MR2
## MR1 1.0 0.7
## MR2 0.7 1.0
##
## Mean item complexity =  1
## Test of the hypothesis that 2 factors are sufficient.
##
## The degrees of freedom for the null model are  55  and the objective
function was  6.7 with Chi Square of  5427.22
## The degrees of freedom for the model are 34  and the objective function
was  0.27
##
## The root mean square of the residuals (RMSR) is  0.03
## The df corrected root mean square of the residuals is  0.04
##
## The harmonic number of observations is  816 with the empirical chi square
71.29  with prob <  0.00019
```

```
## The total number of observations was  816  with Likelihood Chi Square =
214.76  with prob <  4.1e-28
##
## Tucker Lewis Index of factoring reliability =  0.945
## RMSEA index =  0.081  and the 90 % confidence intervals are  0.071 0.091
## BIC =  -13.19
## Fit based upon off diagonal values = 1
## Measures of factor score adequacy
##                                                    MR1  MR2
## Correlation of (regression) scores with factors   0.95 0.95
## Multiple R square of scores with factors          0.91 0.90
## Minimum correlation of possible factor scores     0.82 0.79
```

```
print(fit_v2$loadings)
```

```
##
## Loadings:
##     MR1    MR2
## Q8b  0.117  0.712
## Q8d  0.609  0.154
## Q8f -0.107  0.856
## Q8e         0.740
## Q8g         0.754
## Q8i  0.789
## Q8j         0.727
## Q8l  0.665  0.130
## Q8m  0.755
## Q8n  0.831
## Q8o  0.846
##
##                  MR1   MR2
## SS loadings    3.449 2.929
## Proportion Var 0.314 0.266
## Cumulative Var 0.314 0.580
```

```
corstars(agencyQ1.3) #good!
```

```
##          Q8b      Q8d      Q8f      Q8e      Q8g      Q8i      Q8j
## Q8b
## Q8d  0.53***
## Q8f  0.58***  0.40***
## Q8e  0.68***  0.52***  0.62***
## Q8g  0.61***  0.42***  0.64***  0.55***
## Q8i  0.47***  0.60***  0.33***  0.43***  0.43***
## Q8j  0.61***  0.48***  0.58***  0.63***  0.62***  0.46***
## Q8l  0.50***  0.52***  0.47***  0.50***  0.44***  0.55***  0.48***
## Q8m  0.44***  0.57***  0.34***  0.47***  0.42***  0.62***  0.44***
## Q8n  0.51***  0.57***  0.44***  0.51***  0.45***  0.61***  0.45***
## Q8o  0.48***  0.55***  0.40***  0.43***  0.46***  0.60***  0.45***
##          Q8l      Q8m      Q8n
## Q8b
```

```
## Q8d
## Q8f
## Q8e
## Q8g
## Q8i
## Q8j
## Q8l
## Q8m  0.55***
## Q8n  0.68***  0.58***
## Q8o  0.64***  0.59***  0.73***
```

```
# Descriptive Statistics.
describe(agencyQ1.3)
```

```
## agencyQ1.3
##
##  11  Variables      816  Observations
## ---------------------------------------------------------------------------
-
## Q8b
##        n  missing distinct     Info     Mean      Gmd
##      441      375        7    0.926    4.313    1.234
##
## Value          0     1     2     3     4     5     6
## Frequency      1     7    20    65   142   144    62
## Proportion 0.002 0.016 0.045 0.147 0.322 0.327 0.141
## ---------------------------------------------------------------------------
-
## Q8d
##        n  missing distinct     Info     Mean      Gmd
##      441      375        6    0.933    4.556    1.233
##
## Value          1     2     3     4     5     6
## Frequency      1    17    63   116   143   101
## Proportion 0.002 0.039 0.143 0.263 0.324 0.229
## ---------------------------------------------------------------------------
-
## Q8f
##        n  missing distinct     Info     Mean      Gmd
##      441      375        7    0.938    4.345    1.399
##
## Value          0     1     2     3     4     5     6
## Frequency      1    11    33    56   111   147    82
## Proportion 0.002 0.025 0.075 0.127 0.252 0.333 0.186
## ---------------------------------------------------------------------------
-
## Q8e
##        n  missing distinct     Info     Mean      Gmd
##      441      375        7    0.929     4.46    1.307
##
```

```
## Value          0     1     2     3     4     5     6
## Frequency      2     7    25    46   121   152    88
## Proportion 0.005 0.016 0.057 0.104 0.274 0.345 0.200
## ---------------------------------------------------------------------------
-
## Q8g
##        n  missing distinct     Info     Mean      Gmd
##      441      375        6    0.931    4.263    1.247
##
## Value          1     2     3     4     5     6
## Frequency      4    28    75   133   143    58
## Proportion 0.009 0.063 0.170 0.302 0.324 0.132
## ---------------------------------------------------------------------------
-
## Q8i
##        n  missing distinct     Info     Mean      Gmd
##      441      375        6    0.935    4.522    1.313
##
## Value          1     2     3     4     5     6
## Frequency      4    24    63    99   149   102
## Proportion 0.009 0.054 0.143 0.224 0.338 0.231
## ---------------------------------------------------------------------------
-
## Q8j
##        n  missing distinct     Info     Mean      Gmd
##      441      375        7    0.945    4.122    1.377
##
## Value          0     1     2     3     4     5     6
## Frequency      1    11    29    93   127   118    62
## Proportion 0.002 0.025 0.066 0.211 0.288 0.268 0.141
## ---------------------------------------------------------------------------
-
## Q8l
##        n  missing distinct     Info     Mean      Gmd
##      441      375        5     0.92     4.66    1.142
##
## Value          2     3     4     5     6
## Frequency     10    57   109   162   103
## Proportion 0.023 0.129 0.247 0.367 0.234
## ---------------------------------------------------------------------------
-
## Q8m
##        n  missing distinct     Info     Mean      Gmd
##      441      375        5    0.927    4.639    1.177
##
## Value          2     3     4     5     6
## Frequency     12    57   117   147   108
## Proportion 0.027 0.129 0.265 0.333 0.245
## ---------------------------------------------------------------------------
-
```

```
## Q8n
##        n  missing distinct     Info     Mean      Gmd
##      441      375        5    0.913    4.755    1.081
##
## Value          2     3     4     5     6
## Frequency      6    46   110   167   112
## Proportion 0.014 0.104 0.249 0.379 0.254
## ---------------------------------------------------------------------------
-
## Q8o
##        n  missing distinct     Info     Mean      Gmd
##      441      375        5     0.92    4.735    1.105
##
## Value          2     3     4     5     6
## Frequency      3    55   113   155   115
## Proportion 0.007 0.125 0.256 0.351 0.261
## ---------------------------------------------------------------------------
-
```

—-CONFIRMATORY FACTOR ANALYSIS —– Below I will conduct a confirmatory factor analysis with the FGCS sample

```
fgcs_study1 <- subset(career_imp, parented == 1)
```

In dataframe Intentionality/reactiveness Q8b [116] Q8f [121] Q8e [120] Q8g [122] Q8j [125]

Forethought/reflectiveness Q8d [119] Q8i [124] Q8l [127] Q8m [128] Q8n [129] Q8o [130]

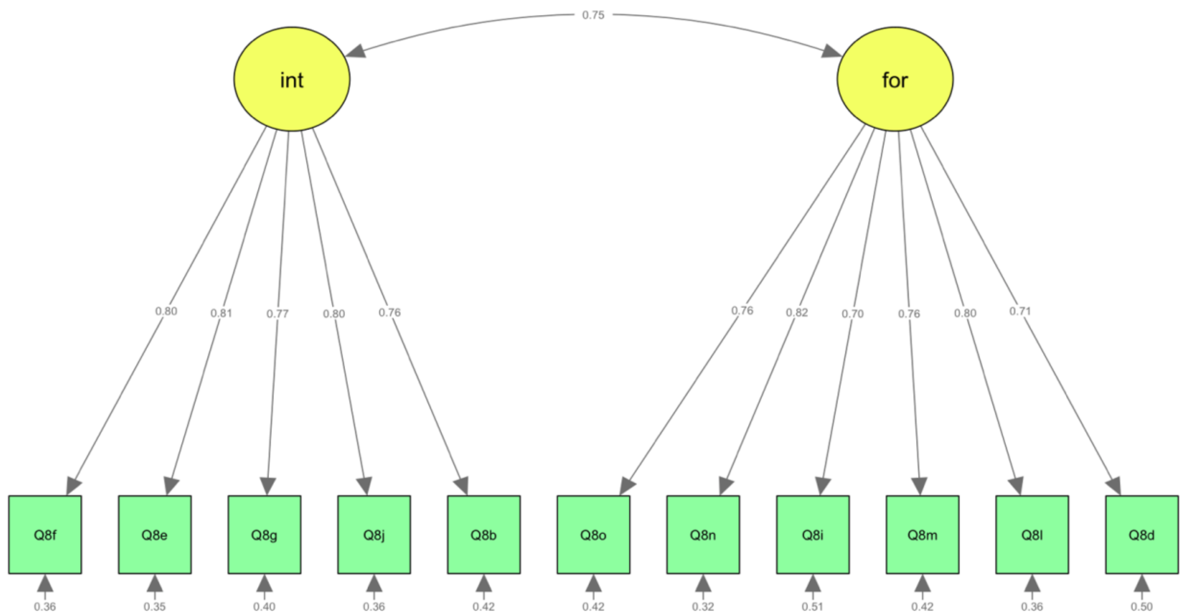
```
Pagency <- '
  intent =~ Q8f + Q8e + Q8g + Q8j + Q8b
  fore =~ Q8o + Q8n + Q8i + Q8m + Q8l + Q8d

 intent ~~ fore
'

fit <- cfa(Pagency, data = fgcs_study1, std.lv = TRUE,
                test = "satorra.bentler", missing = "listwise",
                estimator = "MLM")

summary(fit, fit.measures = T, standardized = T, modindices = F, rsq = T)
```

```
## lavaan 0.6-3 ended normally after 17 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                         23
##
##                                                   Used       Total
```

```
##   Number of observations                           749         821
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                     264.991     138.504
##   Degrees of freedom                                43          43
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.913
##     for the Satorra-Bentler correction
##
## Model test baseline model:
##
##   Minimum Function Test Statistic             5057.923    3117.818
##   Degrees of freedom                                55          55
##   P-value                                        0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                    0.956       0.969
##   Tucker-Lewis Index (TLI)                       0.943       0.960
##
##   Robust Comparative Fit Index (CFI)                         0.963
##   Robust Tucker-Lewis Index (TLI)                            0.953
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)             -11480.076  -11480.076
##   Loglikelihood unrestricted model (H1)     -11347.580  -11347.580
##
##   Number of free parameters                         23          23
##   Akaike (AIC)                               23006.152   23006.152
##   Bayesian (BIC)                             23112.383   23112.383
##   Sample-size adjusted Bayesian (BIC)        23039.349   23039.349
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.083       0.054
##   90 Percent Confidence Interval          0.074  0.093       0.047  0.062
##   P-value RMSEA <= 0.05                          0.000       0.153
##
##   Robust RMSEA                                               0.075
##   90 Percent Confidence Interval                             0.061  0.090
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.044       0.044
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
```

```
##   Standard Errors                              Robust.sem
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   intent =~
##     Q8f               1.148    0.048   24.149    0.000    1.148    0.803
##     Q8e               1.037    0.044   23.388    0.000    1.037    0.806
##     Q8g               1.021    0.045   22.551    0.000    1.021    0.779
##     Q8j               1.137    0.044   25.893    0.000    1.137    0.799
##     Q8b               0.992    0.044   22.724    0.000    0.992    0.766
##   fore =~
##     Q8o               0.932    0.042   22.237    0.000    0.932    0.775
##     Q8n               0.995    0.040   25.161    0.000    0.995    0.829
##     Q8i               0.981    0.046   21.180    0.000    0.981    0.709
##     Q8m               1.023    0.047   21.615    0.000    1.023    0.759
##     Q8l               1.001    0.041   24.613    0.000    1.001    0.808
##     Q8d               0.896    0.044   20.303    0.000    0.896    0.717
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   intent ~~
##     fore              0.753    0.026   28.436    0.000    0.753    0.753
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q8f               0.723    0.070   10.350    0.000    0.723    0.354
##    .Q8e               0.579    0.061    9.512    0.000    0.579    0.350
##    .Q8g               0.677    0.056   12.151    0.000    0.677    0.394
##    .Q8j               0.732    0.067   10.854    0.000    0.732    0.362
##    .Q8b               0.692    0.067   10.329    0.000    0.692    0.413
##    .Q8o               0.577    0.065    8.850    0.000    0.577    0.399
##    .Q8n               0.450    0.044   10.314    0.000    0.450    0.312
##    .Q8i               0.955    0.090   10.560    0.000    0.955    0.498
##    .Q8m               0.773    0.090    8.617    0.000    0.773    0.425
##    .Q8l               0.533    0.048   10.999    0.000    0.533    0.347
##    .Q8d               0.760    0.072   10.499    0.000    0.760    0.486
##     intent            1.000                               1.000    1.000
##     fore              1.000                               1.000    1.000
##
## R-Square:
##                    Estimate
##     Q8f               0.646
##     Q8e               0.650
##     Q8g               0.606
##     Q8j               0.638
##     Q8b               0.587
##     Q8o               0.601
##     Q8n               0.688
##     Q8i               0.502
##     Q8m               0.575
```

```
##     Q8l               0.653
##     Q8d               0.514

###generate the SEM image
semPaths(fit, what = "path", "std", "lisrel",
         layout = "tree2", sizeMan = 5,
         sizeMan2 = 6,
         intercepts = FALSE,
         residuals = TRUE,
         curve = 1.5,
         rotation = 1,
         color = list(lat = rgb(245, 253, 118, maxColorValue = 255),
                      man = rgb(155, 253, 175, maxColorValue = 255)),
         mar = c(10, 5, 10, 5))
```




```
reliability(fit)

##           intent      fore     total
## alpha  0.8923060 0.8928484 0.9235048
## omega  0.8931769 0.8935489 0.9361451
## omega2 0.8931769 0.8935489 0.9361451
## omega3 0.8933891 0.8945322 0.9304692
## avevar 0.6266064 0.5836521 0.6044395

cronbach(fgcs_study1[,c(116, 117, 120, 121,125)])
#intentionality/reactiveness --> 0.87

## $sample.size
## [1] 769
##
## $number.of.items
```

```
## [1] 5
##
## $alpha
## [1] 0.828863
```

```
cronbach(fgcs_study1[,c(119, 124,127:130)]) #reflectiveness/forethought --
>0.886
```

```
## $sample.size
## [1] 756
##
## $number.of.items
## [1] 6
##
## $alpha
## [1] 0.8673224
```

THIS IS THE CFA THAT APPEARS IN MY STUDY 1

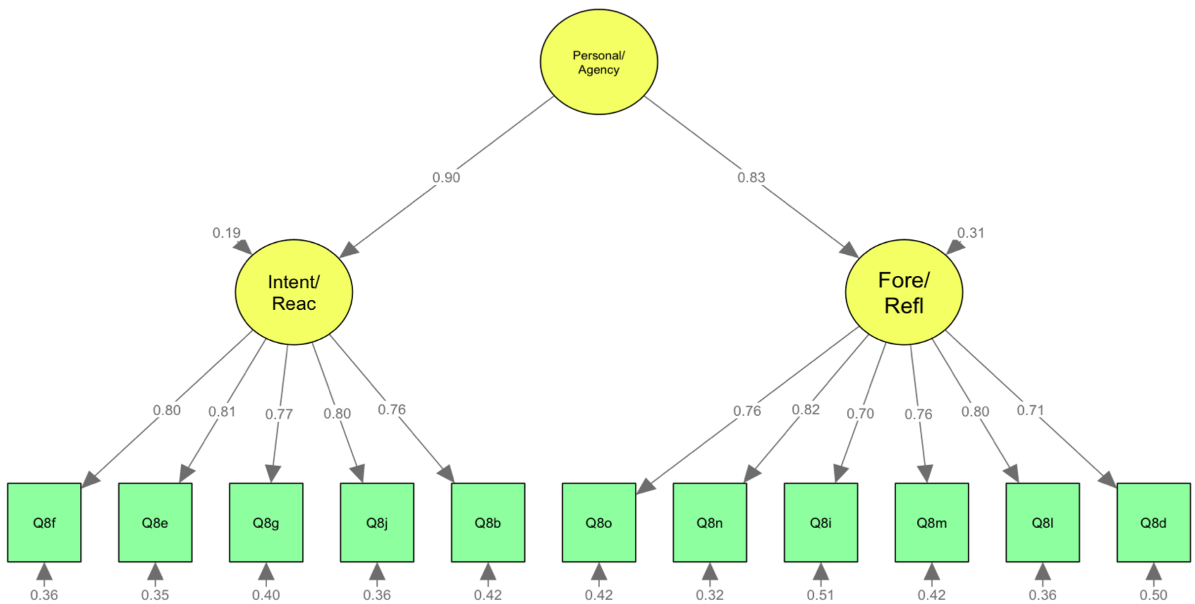
```
cfa_agency <- '
intent =~ na*Q8f + Q8e + Q8g + Q8j + Q8b
fore =~ na*Q8o + Q8n + Q8i + Q8m + Q8l + Q8d

agency =~ intent + fore

agency ~~1*agency

'

fit_agency <- cfa(cfa_agency, data = fgcs_study1, std.lv = TRUE, test =
"satorra.bentler",
                  missing = "listwise", estimator = "MLM")
summary(fit_agency, fit.measures = T, standardized = T, rsq = T)
```

```
## lavaan 0.6-3 ended normally after 30 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                         24
##   Number of equality constraints                     1
##
##                                                   Used       Total
##   Number of observations                           749         821
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                     264.991     138.504
##   Degrees of freedom                                43          43
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.913
##     for the Satorra-Bentler correction
```

```
##
## Model test baseline model:
##
##   Minimum Function Test Statistic             5057.923    3117.818
##   Degrees of freedom                                55          55
##   P-value                                        0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                    0.956       0.969
##   Tucker-Lewis Index (TLI)                       0.943       0.960
##
##   Robust Comparative Fit Index (CFI)                         0.963
##   Robust Tucker-Lewis Index (TLI)                            0.953
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)             -11480.076  -11480.076
##   Loglikelihood unrestricted model (H1)     -11347.580  -11347.580
##
##   Number of free parameters                         23          23
##   Akaike (AIC)                               23006.152   23006.152
##   Bayesian (BIC)                             23112.383   23112.383
##   Sample-size adjusted Bayesian (BIC)        23039.349   23039.349
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.083       0.054
##   90 Percent Confidence Interval          0.074  0.093       0.047  0.062
##   P-value RMSEA <= 0.05                          0.000       0.153
##
##   Robust RMSEA                                               0.075
##   90 Percent Confidence Interval                             0.061  0.090
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.044       0.044
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard Errors                           Robust.sem
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   intent =~
##     Q8f       (na)    0.507    0.027   19.064    0.000    1.148    0.803
##     Q8e               0.458    0.031   14.816    0.000    1.037    0.806
##     Q8g               0.451    0.029   15.658    0.000    1.021    0.779
```

```
##     Q8j                 0.502    0.031   15.975    0.000    1.137    0.799
##     Q8b                 0.438    0.030   14.541    0.000    0.992    0.766
##   fore =~
##     Q8o       (na)      0.507    0.027   19.064    0.000    0.932    0.775
##     Q8n                 0.542    0.035   15.309    0.000    0.995    0.829
##     Q8i                 0.534    0.034   15.664    0.000    0.981    0.709
##     Q8m                 0.557    0.038   14.589    0.000    1.023    0.759
##     Q8l                 0.545    0.035   15.453    0.000    1.001    0.808
##     Q8d                 0.488    0.031   15.731    0.000    0.896    0.717
##   agency =~
##     intent              2.031    0.144   14.057    0.000    0.897    0.897
##     fore                1.541    0.133   11.598    0.000    0.839    0.839
##
## Variances:
##                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     agency              1.000                               1.000    1.000
##    .Q8f                 0.723    0.070   10.350    0.000    0.723    0.354
##    .Q8e                 0.579    0.061    9.512    0.000    0.579    0.350
##    .Q8g                 0.677    0.056   12.151    0.000    0.677    0.394
##    .Q8j                 0.732    0.067   10.854    0.000    0.732    0.362
##    .Q8b                 0.692    0.067   10.329    0.000    0.692    0.413
##    .Q8o                 0.577    0.065    8.850    0.000    0.577    0.399
##    .Q8n                 0.450    0.044   10.314    0.000    0.450    0.312
##    .Q8i                 0.955    0.090   10.560    0.000    0.955    0.498
##    .Q8m                 0.773    0.090    8.617    0.000    0.773    0.425
##    .Q8l                 0.533    0.048   10.999    0.000    0.533    0.347
##    .Q8d                 0.760    0.072   10.499    0.000    0.760    0.486
##     intent              1.000                               0.195    0.195
##     fore                1.000                               0.296    0.296
##
## R-Square:
##                      Estimate
##     Q8f                 0.646
##     Q8e                 0.650
##     Q8g                 0.606
##     Q8j                 0.638
##     Q8b                 0.587
##     Q8o                 0.601
##     Q8n                 0.688
##     Q8i                 0.502
##     Q8m                 0.575
##     Q8l                 0.653
##     Q8d                 0.514
##     intent              0.805
##     fore                0.704

###generate the SEM image
lbs <- c("Q8f", "Q8e", "Q8g", "Q8j", "Q8b", "Q8o", "Q8n", "Q8i", "Q8m",
"Q8l", "Q8d", "Intent/\nReac", "Fore/\nRefl", "Personal/\nAgency")
```

```r
semPaths(fit_agency, what = "path", "std", "lisrel",
         layout = "tree2", sizeMan = 5, sizeMan2 = 6,
         intercepts = FALSE,
         residuals = TRUE, edge.label.cex= 0.75,
         sizeInt = 12,  curve = 1.5, rotation = 1,
         nodeLabels= lbs,
         color = list(lat = rgb(245, 253, 118,
                                maxColorValue = 255),
                      man = rgb(155, 253, 175,
                                maxColorValue = 255)),
         mar = c(10, 5, 10, 5))
```




```r
reliability(fit_agency)

##           intent      fore     total
## alpha  0.8923060 0.8928484 0.9235048
## omega  0.8931769 0.8935489 0.9361451
## omega2 0.8931769 0.8935489 0.9361451
## omega3 0.8933894 0.8945317 0.9304689
## avevar 0.6266064 0.5836522 0.6044396

cronbach(fgcs_study1[,c(119, 127, 122:124)]) #intentionality/reactiveness -->
0.89

## $sample.size
## [1] 764
##
## $number.of.items
## [1] 5
##
```

```
## $alpha
## [1] 0.8915439
```

```r
cronbach(fgcs_study1[,c(121, 126, 129, 130:132)])
#intentionality/reactiveness --> 0.89
```

```
## $sample.size
## [1] 764
##
## $number.of.items
## [1] 6
##
## $alpha
## [1] 0.8917255
```

APPENDIX C. CORRELATION MATRIX FOR PERSONAL AGENCY QUESTIONS USING PILOT-SCALE DATASET

Table 3.3. Correlation Matrix for Personal Agency Questions using Pilot Dataset Collected Spring 2017

	Q1a	Q1b	Q1c	Q1d	Q1e	Q1f	Q1g	Q1h	Q1i	Q1j	Q1k	Q1l	Q1m	Q1n	Q1o	Q1p	Q1q	Q1r	Q1s	Q1t	Q1u	Q1v	Q1w	Q1x	Q1y
Q1a																									
Q1b	0.68***																								
Q1c	0.52***	0.62***																							
Q1d	0.43***	0.55***	0.56***																						
Q1e	0.48***	0.43***	0.36***	0.55***																					
Q1f	0.35***	0.34***	0.24*	0.36***	0.39***																				
Q1g	0.43***	0.50***	0.45***	0.46***	0.51***	0.45***																			
Q1h	-0.04	-0.1	-0.14	-0.04	-0.13	-0.13	-0.11																		
Q1i	0.41***	0.58***	0.51***	0.46***	0.48***	0.47***	0.52***	-0.20*																	
Q1j	0.44***	0.52***	0.55***	0.50***	0.44***	0.42***	0.40***	-0.28**	0.65***																
Q1k	0.36***	0.41***	0.57***	0.44***	0.33***	0.22*	0.29**	-0.23*	0.43***	0.59***															
Q1l	0.47***	0.67***	0.51***	0.53***	0.43***	0.34***	0.50***	-0.1	0.58***	0.54***	0.42***														
Q1m	0.42***	0.48***	0.30**	0.43***	0.37***	0.30**	0.38***	-0.11	0.45***	0.37***	0.18	0.55***													
Q1n	0.44***	0.51***	0.39***	0.46***	0.38***	0.14	0.23*	0.05	0.34***	0.33***	0.32***	0.46***	0.44***												
Q1o	0.43***	0.56***	0.57***	0.44***	0.30**	0.27**	0.39***	-0.20*	0.40***	0.37***	0.39***	0.42***	0.37***	0.52***											
Q1p	0.41***	0.61***	0.48***	0.42***	0.29**	0.25**	0.41***	0.12	0.50***	0.36***	0.28**	0.56***	0.32***	0.32***	0.46***										
Q1q	0.40***	0.47***	0.38***	0.31***	0.33***	0.17	0.59***	0.04	0.53***	0.33***	0.25**	0.56***	0.49***	0.38***	0.34***	0.56***									
Q1r	-0.05	-0.1	-0.1	-0.13	-0.20*	0.01	-0.04	0.41***	-0.21*	-0.15	-0.18	-0.17	-0.07	0.04	-0.04	00	-0.08								
Q1s	0.36***	0.39***	0.50***	0.47***	0.41***	0.25**	0.35***	-0.15	0.55***	0.44***	0.42***	0.43***	0.41***	0.22*	0.42***	0.35***	0.36***	-0.30**							
Q1t	0.51***	0.49***	0.51***	0.50***	0.44***	0.24*	0.45***	-0.09	0.45***	0.49***	0.43***	0.47***	0.53***	0.43***	0.40***	0.31***	0.37***	-0.04	0.50***						
Q1u	0.39***	0.45***	0.57***	0.40***	0.34***	0.15	0.39***	-0.11	0.50***	0.46***	0.52***	0.47***	0.33***	0.44***	0.58***	0.43***	0.42***	-0.07	0.49***	0.52***					
Q1v	0.35***	0.30**	0.35***	0.28**	0.25**	0.57***	0.21*	-0.16	0.38***	0.42***	0.38***	0.35***	0.27**	0.27**	0.35***	0.25**	0.22*	-0.1	0.26**	0.28**	0.20*				
Q1w	-0.04	-0.07	-0.04	-0.15	-0.28**	-0.09	-0.07	0.46***	-0.22*	-0.16	-0.21*	-0.12	-0.1	-0.06	-0.1	0.03	-0.12	0.64***	-0.18	-0.04	-0.11	-0.09			
Q1x	0.40***	0.36***	0.54***	0.40***	0.34***	0.23*	0.39***	-0.21*	0.48***	0.40***	0.49***	0.29**	0.36***	0.31***	0.39***	0.26**	0.37***	-0.20*	0.59***	0.56***	0.44***	0.41***	-0.27**		
Q1y	0.34***	0.21*	0.15	0.26**	0.33***	0.63***	0.22*	-0.11	0.34***	0.26**	0.18	0.23*	0.22*	0.18	0.18	0.15	0.10	-0.06	0.17	0.10	0.22*	0.42***	-0.28**	0.21*	
Q1z	0.57***	0.50***	0.39***	0.47***	0.50***	0.41***	0.39***	-0.11	0.54***	0.47***	0.42***	0.50***	0.37***	0.43***	0.29**	0.39***	0.39***	-0.1	0.38***	0.47***	0.50***	0.25**	-0.20*	0.38***	0.45***

APPENDIX D. CORRELATION MATRIX FOR PERSONAL AGENCY QUESTIONS USING LARGE-SCALE DATASET

Table 3.5. Correlation Matrix for Personal Agency Questions using Large-Scale Dataset of First-Generation College Student Population Collected Fall 2017

		Q8b	Q8d	Q8f	Q8e	Q8g	Q8i	Q8j	Q8l	Q8m	Q8n
Reac.	Q8b										
Fore.	Q8d	0.53***									
Reac.	Q8f	0.58***	0.40***								
Int.	Q8e	0.68***	0.52***	0.62***							
Int.	Q8g	0.61***	0.42***	0.64***	0.55***						
Fore.	Q8i	0.47***	0.60***	0.33***	0.43***	0.43***					
Reac.	Q8j	0.61***	0.48***	0.58***	0.63***	0.62***	0.46***				
Refl.	Q8l	0.50***	0.52***	0.47***	0.50***	0.44***	0.55***	0.48***			
Fore.	Q8m	0.44***	0.57***	0.34***	0.47***	0.42***	0.62***	0.44***	0.55***		
Refl.	Q8n	0.51***	0.57***	0.44***	0.51***	0.45***	0.61***	0.45***	0.68***	0.58***	
Refl.	Q8o	0.48***	0.55***	0.40***	0.43***	0.46***	0.60***	0.45***	0.64***	0.59***	0.73***

APPENDIX E. SURVEY CODEBOOK USED IN STUDY 2 FOR LARGE-SCALE DATASET COLLECTED FALL 2017

Q3. To what extent do you agree or disagree with the following statements?
Q3Eng_a = I feel like an ENGINEER now.
Q3Eng_b = I will feel like an ENGINEER in the future.
Q3Eng_c = I see myself as an ENGINEER.
Q3Eng_d = My parents see me as an ENGINEER.
Q3Eng_e = My instructors see me as an ENGINEER.
Q3Eng_f = My peers see me as an ENGINEER.
Q3Eng_g = I've had experiences in which I was recognized as an ENGINEER.
Q3Eng_h = I am interested in learning more about ENGINEERING.
Q3Eng_i = I enjoy learning ENGINEERING.
Q3Eng_j = I find fulfillment in doing ENGINEERING.
Q3Eng_k = I am confident that I can understand ENGINEERING in class.
Q3Eng_l = I am confident that I can understand ENGINEERING outside of class.
Q3Eng_m = I can do well on exams in ENGINEERING.
Q3Eng_n = I understand concepts I have studied in ENGINEERING.
Q3Eng_o = Others ask me for help in engineering.

VALUES: 0 through 6 (rating scale); 0 = "strongly disagree", 6 = "strongly agree", . = missing

Q5. To what extent do you agree or disagree with the following statements?
Q5a = I can make changes in my community with engineering.
Q5b = Engineering can improve our society.
Q5c = Engineering will give me the tools and resources to make an impact in my community.
Q5d = Engineering can improve quality of life.
Q5e = Engineering can be a resource for my community.
Q5f = I can make an impact in peoples' lives through engineering.
Q5g = Engineering can improve the quality of life in my community.
Q5h = Engineering knowledge is for the advancement of human welfare.

VALUES: 0 through 6 (rating scale); 0 = "strongly disagree", 6 = "strongly agree", . = missing

Q8. To what extent do you agree or disagree with the following statements:
Q8a = I make purposeful decisions about how to accomplish my plans.
Q8b = I monitor my actions to achieve my goals.
Q8c = I think about my experiences so I can learn from them.
Q8d = I consider many courses of action before making plans.
Q8e = I set goals that are achievable.
Q8f = I keep myself motivated to reach my goals
Q8g = My plans become actions.
Q8h = I reflect on the way others do something to think of a better way of doing it.
Q8i = I weigh the pros and cons before executing an action.
Q8j = I actively keep myself on track to complete my plans.

Q8k = I have a specific purpose when I make a commitment.
Q8l = I reflect on my actions to see if I could have made improvements.
Q8m = I anticipate potential consequences when making plans.
Q8n = I think about my experiences to improve on my next performance.
Q8o = I think over what I have done to consider alternative ways of doing it.

VALUES: 0 through 6 (rating scale); 0 = “strongly disagree”, 6 = “strongly agree”, " "= missing

Q12. To what extent to you agree or disagree with the following statements?
Q12Phys_a = I see myself as a PHYSICS person
Q12Phys_b = My parents see me as a PHYSICS person
Q12Phys_c = My instructors see me as a PHYSICS person
Q12Phys_d = My peers see me as a PHYSICS person
Q12Phys_e = I’ve had experiences in which I was recognized as a PHYSICS person
Q12Phys_f = I am interested in learning more about PHYSICS
Q12Phys_g = I enjoy learning PHYSICS
Q12Phys_h = I find fulfillment in doing PHYSICS
Q12Phys_i = I am confident that I can understand PHYSICS in class
Q12Phys_j = I am confident that I can understand PHYSICS outside of class
Q12Phys_k = I can do well on exams in PHYSICS
Q12Phys_l = I understand concepts I have studied in PHYISCS
Q12Phys_m = Others ask me for help in PHYSICS
Q12Phys_n = I can overcome setbacks in PHYSICS
Q12Math_a = I see myself as a MATH person
Q12Math_b = My parents see me as a MATH person
Q12Math_c = My instructors see me as a MATH person
Q12Math_d = My peers see me as a MATH person
Q12Math_e = I’ve had experiences in which I was recognized as a MATH person
Q12Math_f = I am interested in learning more about MATH
Q12Math_g = I enjoy learning MATH
Q12Math_h = I find fulfillment in doing MATH
Q12Math_i = I am confident that I can understand MATH in class
Q12Math_j = I am confident that I can understand MATH outside of class
Q12Math_k = I can do well on exams in MATH
Q12Math_l = I understand concepts I have studied in MATH
Q12Math_m = Others ask me for help in MATH
Q12Math_n = I can overcome setbacks in MATH
VALUES: 0 through 6 (rating scale); 0 = “strongly disagree”, 6 = “strongly agree”, . = missing

APPENDIX F. R CODE USED IN STUDY 2

R code for Study 2 can be found in the next page.

R CODE USED IN STUDY 2

```
library(psych)
library(car)
library(nFactors)
library(lm.beta)
library(psy) #has cronbach
library(lavaan)
library(GPArotation)
library(semTools)
library(ggplot2)
library(nonnest2)
library(MVN)
library(Amelia)
library(xtable)
library(SemiParSampleSel)

load("~/Documents/Research
Projects/CAREER/Datasets/V2_20180625_CAREER_imputed.RData")

setwd("~/Documents/Research Projects/Af PRELIM/Study 2")

career_imp$parented <- ifelse(career_imp$Q34a <=3 & career_imp$Q34b <=3 |
                            career_imp$Q34a <=3 & career_imp$Q34b ==6 |
                           career_imp$Q34a ==6 & career_imp$Q34b <=3, 1, 0)

table(career_imp$parented, useNA = 'always')

##
##    0    1 <NA>
## 2057  804  850

study2 <- career_imp[!(is.na(career_imp$parented)),] #this line removes the
850 NAs

study2 <- subset(study2, study2$parented == 1) #this line creates a FGCS
dataframe

study2_FYE <- subset(study2, study2$Q18a == 1)

##only those that identify as Women & Men
study2_FYE <- subset(study2_FYE, study2_FYE$Q31a ==1 | study2_FYE$Q31b ==1)

#study2_FYE$parainflu <- ifelse(study2_FYE$Q29a == 1 | study2_FYE$Q29b == 1,
1, 0)

describe(study2_FYE[,c(48:62, 71:78, 118, 119, 121:127, 129:132,157:184)])
```

```
##             vars   n mean   sd median trimmed  mad min max range  skew
## Q3Eng_a        1 587 2.45 1.60      3    2.40 1.48   0   6     6  0.20
## Q3Eng_b        2 587 4.79 1.41      5    5.01 1.48   0   6     6 -1.37
## Q3Eng_c        3 583 4.27 1.68      5    4.50 1.48   0   6     6 -0.86
## Q3Eng_d        4 585 4.32 1.63      5    4.54 1.48   0   6     6 -0.88
## Q3Eng_e        5 579 3.55 1.55      3    3.62 1.48   0   6     6 -0.29
## Q3Eng_f        6 574 3.74 1.58      4    3.84 1.48   0   6     6 -0.36
## Q3Eng_g        7 579 3.31 1.91      4    3.38 1.48   0   6     6 -0.31
## Q3Eng_h        8 580 5.20 1.19      6    5.45 0.00   0   6     6 -1.90
## Q3Eng_i        9 581 5.02 1.27      5    5.24 1.48   0   6     6 -1.51
## Q3Eng_j       10 577 4.81 1.34      5    5.01 1.48   0   6     6 -1.16
## Q3Eng_k       11 584 4.55 1.34      5    4.71 1.48   0   6     6 -0.90
## Q3Eng_l       12 584 4.46 1.37      5    4.60 1.48   0   6     6 -0.74
## Q3Eng_m       13 580 4.14 1.42      4    4.25 1.48   0   6     6 -0.70
## Q3Eng_n       14 578 4.37 1.28      5    4.46 1.48   0   6     6 -0.71
## Q3Eng_o       15 581 3.48 1.66      4    3.56 1.48   0   6     6 -0.36
## Q5a           16 579 4.51 1.39      5    4.67 1.48   0   6     6 -0.83
## Q5b           17 577 5.26 1.05      6    5.46 0.00   1   6     5 -1.50
## Q5c           18 578 5.03 1.08      5    5.19 1.48   0   6     6 -1.10
## Q5d           19 578 5.20 1.03      6    5.38 0.00   1   6     5 -1.25
## Q5e           20 577 5.09 1.04      5    5.23 1.48   0   6     6 -1.25
## Q5f           21 579 5.02 1.17      5    5.22 1.48   0   6     6 -1.44
## Q5g           22 574 5.08 1.13      5    5.28 1.48   0   6     6 -1.41
## Q5h           23 574 5.04 1.18      5    5.24 1.48   0   6     6 -1.46
## Q8a           24 578 4.40 1.28      4    4.50 1.48   0   6     6 -0.67
## Q8b           25 575 4.27 1.26      4    4.34 1.48   0   6     6 -0.42
## Q8d           26 575 4.45 1.21      5    4.54 1.48   0   6     6 -0.55
## Q8e           27 575 4.47 1.30      5    4.60 1.48   0   6     6 -0.72
## Q8f           28 576 4.27 1.42      4    4.40 1.48   0   6     6 -0.71
## Q8g           29 574 4.25 1.31      4    4.33 1.48   0   6     6 -0.61
## Q8h           30 574 4.44 1.23      5    4.54 1.48   0   6     6 -0.68
## Q8i           31 572 4.44 1.30      5    4.56 1.48   0   6     6 -0.67
## Q8j           32 572 4.06 1.39      4    4.14 1.48   0   6     6 -0.44
## Q8l           33 574 4.60 1.22      5    4.72 1.48   0   6     6 -0.80
## Q8m           34 571 4.47 1.29      5    4.59 1.48   0   6     6 -0.77
## Q8n           35 571 4.64 1.16      5    4.74 1.48   0   6     6 -0.67
## Q8o           36 574 4.63 1.19      5    4.74 1.48   0   6     6 -0.74
## Q12Phys_a     37 563 3.60 1.63      4    3.69 1.48   0   6     6 -0.37
## Q12Phys_b     38 557 3.64 1.76      4    3.77 1.48   0   6     6 -0.35
## Q12Phys_c     39 552 3.36 1.50      3    3.40 1.48   0   6     6 -0.23
## Q12Phys_d     40 539 3.58 1.67      3    3.68 1.48   0   6     6 -0.33
## Q12Phys_e     41 556 3.45 1.98      4    3.56 1.48   0   6     6 -0.35
## Q12Phys_f     42 560 4.73 1.53      5    4.99 1.48   0   6     6 -1.16
## Q12Phys_g     43 560 4.34 1.66      5    4.54 1.48   0   6     6 -0.79
## Q12Phys_h     44 555 3.94 1.76      4    4.12 1.48   0   6     6 -0.60
## Q12Phys_i     45 557 4.10 1.58      4    4.24 1.48   0   6     6 -0.63
## Q12Phys_j     46 552 3.99 1.59      4    4.12 1.48   0   6     6 -0.55
## Q12Phys_k     47 557 3.82 1.63      4    3.96 1.48   0   6     6 -0.49
## Q12Phys_l     48 558 4.14 1.58      4    4.29 1.48   0   6     6 -0.65
## Q12Phys_m     49 552 3.53 1.84      4    3.66 1.48   0   6     6 -0.37
```

```
## Q12Phys_n   50 554 4.16 1.52      4    4.31 1.48   0   6     6 -0.69
## Q12Math_a   51 565 4.59 1.37      5    4.76 1.48   0   6     6 -1.05
## Q12Math_b   52 565 4.90 1.37      5    5.12 1.48   0   6     6 -1.27
## Q12Math_c   53 555 3.98 1.49      4    4.09 1.48   0   6     6 -0.51
## Q12Math_d   54 542 4.42 1.53      5    4.61 1.48   0   6     6 -0.90
## Q12Math_e   55 559 4.60 1.52      5    4.83 1.48   0   6     6 -1.11
## Q12Math_f   56 556 4.72 1.48      5    4.95 1.48   0   6     6 -1.14
## Q12Math_g   57 559 4.58 1.47      5    4.79 1.48   0   6     6 -1.00
## Q12Math_h   58 559 4.45 1.55      5    4.66 1.48   0   6     6 -0.90
## Q12Math_i   59 559 4.59 1.35      5    4.74 1.48   0   6     6 -0.98
## Q12Math_j   60 559 4.48 1.39      5    4.64 1.48   0   6     6 -0.82
## Q12Math_k   61 560 4.37 1.45      5    4.54 1.48   0   6     6 -0.80
## Q12Math_l   62 560 4.63 1.31      5    4.77 1.48   0   6     6 -0.89
## Q12Math_m   63 560 4.37 1.69      5    4.62 1.48   0   6     6 -0.96
## Q12Math_n   64 559 4.62 1.38      5    4.80 1.48   0   6     6 -1.08
##            kurtosis   se
## Q3Eng_a       -0.60 0.07
## Q3Eng_b        1.69 0.06
## Q3Eng_c       -0.02 0.07
## Q3Eng_d        0.08 0.07
## Q3Eng_e       -0.31 0.06
## Q3Eng_f       -0.42 0.07
## Q3Eng_g       -0.98 0.08
## Q3Eng_h        3.90 0.05
## Q3Eng_i        2.39 0.05
## Q3Eng_j        1.05 0.06
## Q3Eng_k        0.57 0.06
## Q3Eng_l        0.01 0.06
## Q3Eng_m        0.22 0.06
## Q3Eng_n        0.47 0.05
## Q3Eng_o       -0.46 0.07
## Q5a            0.39 0.06
## Q5b            1.89 0.04
## Q5c            1.06 0.05
## Q5d            0.97 0.04
## Q5e            2.08 0.04
## Q5f            2.43 0.05
## Q5g            2.09 0.05
## Q5h            2.50 0.05
## Q8a            0.49 0.05
## Q8b           -0.18 0.05
## Q8d            0.01 0.05
## Q8e            0.11 0.05
## Q8f            0.16 0.06
## Q8g            0.30 0.05
## Q8h            0.20 0.05
## Q8i            0.13 0.05
## Q8j           -0.25 0.06
## Q8l            0.23 0.05
## Q8m            0.44 0.05
```

```
## Q8n          -0.03 0.05
## Q8o           0.26 0.05
## Q12Phys_a    -0.43 0.07
## Q12Phys_b    -0.62 0.07
## Q12Phys_c     0.03 0.06
## Q12Phys_d    -0.46 0.07
## Q12Phys_e    -1.01 0.08
## Q12Phys_f     0.66 0.06
## Q12Phys_g    -0.20 0.07
## Q12Phys_h    -0.44 0.07
## Q12Phys_i    -0.21 0.07
## Q12Phys_j    -0.35 0.07
## Q12Phys_k    -0.42 0.07
## Q12Phys_l    -0.17 0.07
## Q12Phys_m    -0.76 0.08
## Q12Phys_n     0.05 0.06
## Q12Math_a     0.96 0.06
## Q12Math_b     1.24 0.06
## Q12Math_c     0.11 0.06
## Q12Math_d     0.42 0.07
## Q12Math_e     0.81 0.06
## Q12Math_f     0.84 0.06
## Q12Math_g     0.60 0.06
## Q12Math_h     0.31 0.07
## Q12Math_i     0.84 0.06
## Q12Math_j     0.30 0.06
## Q12Math_k     0.25 0.06
## Q12Math_l     0.56 0.06
## Q12Math_m     0.20 0.07
## Q12Math_n     1.12 0.06
```

```
corstars <- function(x){
  require(Hmisc)
  x <- as.matrix(x)
  R <- rcorr(x)$r
  p <- rcorr(x)$P

  ## define notions for significance levels; spacing is important.
  mystars <- ifelse(p < .001, "***", ifelse(p < .01, "** ",
      ifelse(p < .05, "* ", " ")))

  ## trunctuate the matrix that holds the correlations to two decimal
  R <- format(round(cbind(rep(-1.11, ncol(x)), R), 2))[,-1]

  ## build a new matrix that includes the correlations with their apropriate
stars
  Rnew <- matrix(paste(R, mystars, sep=""), ncol=ncol(x))
  diag(Rnew) <- paste(diag(R), " ", sep="")
  rownames(Rnew) <- colnames(x)
  colnames(Rnew) <- paste(colnames(x), "", sep="")
```

```r
  ## remove upper triangle
  Rnew <- as.matrix(Rnew)
  Rnew[upper.tri(Rnew, diag = TRUE)] <- ""
  Rnew <- as.data.frame(Rnew)

  ## remove last column and return the matrix (which is now a data frame)
  Rnew <- cbind(Rnew[1:length(Rnew)-1])
  return(Rnew)
}

corr <- corstars(study2[,c(48:62, 71:78, 118:132, 157:184)])
write.csv(corr, file = "CorrelationMatrix_Study2_06102019.csv")
```

frame <- study2[,c(48:62, 71:78, 118, 119, 121:127, 129:132,157:184)] write.csv(frame, file = “study2_MNVanalysis.csv”) used http://www.biosoft.hacettepe.edu.tr/MVN/ to get mardias test because this fuctions doesn’t work

```r
cronbach(study2[, c(50, 53)]) #Eng Rec --> 0.72

## $sample.size
## [1] 774
##
## $number.of.items
## [1] 2
##
## $alpha
## [1] 0.7221653

cronbach(study2[, c(55:57)]) #Eng Int --> 0.90

## $sample.size
## [1] 771
##
## $number.of.items
## [1] 3
##
## $alpha
## [1] 0.9080941

cronbach(study2[, c(58:61)]) #Eng PC --> 0.89

## $sample.size
## [1] 773
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.887947
```

```r
cronbach(study2[, c(157, 159, 160)]) #Phys Rec --> 0.86
```

```
## $sample.size
## [1] 704
##
## $number.of.items
## [1] 3
##
## $alpha
## [1] 0.8557965
```

```r
cronbach(study2[, c(162:164)]) #Phys Int --> 0.90
```

```
## $sample.size
## [1] 727
##
## $number.of.items
## [1] 3
##
## $alpha
## [1] 0.8977973
```

```r
cronbach(study2[, c(165:168)]) #Phys PC --> 0.93
```

```
## $sample.size
## [1] 723
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.9338199
```

```r
cronbach(study2[, c(171, 173:175)]) #Math Rec --> 0.86
```

```
## $sample.size
## [1] 697
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.8518006
```

```r
cronbach(study2[, c(176:178)]) #Math Int --> 0.88
```

```
## $sample.size
## [1] 733
##
## $number.of.items
## [1] 3
##
```

```
## $alpha
## [1] 0.8725254

cronbach(study2[, c(179:182)]) #Math PC --> 0.92

## $sample.size
## [1] 732
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.9145812

cronbach(study2[, c(73:77)]) #Eng Agency --> 0.92

## $sample.size
## [1] 764
##
## $number.of.items
## [1] 5
##
## $alpha
## [1] 0.9248553

cronbach(study2[, c(119,122:124,127)]) #Personal Agency Intent --> 0.89

## $sample.size
## [1] 747
##
## $number.of.items
## [1] 5
##
## $alpha
## [1] 0.8900527

cronbach(study2[, c(129:132)]) #Personal Agency Forethought --> 0.87

## $sample.size
## [1] 753
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.8680535

######################################################################

cronbach(study2_FYE[, c(50, 53)]) #Eng Rec --> 0.72
```

```
## $sample.size
## [1] 572
##
## $number.of.items
## [1] 2
##
## $alpha
## [1] 0.6978264
```

```r
cronbach(study2_FYE[, c(55:57)]) #Eng Int --> 0.90
```

```
## $sample.size
## [1] 568
##
## $number.of.items
## [1] 3
##
## $alpha
## [1] 0.9037978
```

```r
cronbach(study2_FYE[, c(58:61)]) #Eng PC --> 0.89
```

```
## $sample.size
## [1] 573
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.8866396
```

```r
cronbach(study2_FYE[, c(157, 159, 160)]) #Phys Rec --> 0.86
```

```
## $sample.size
## [1] 531
##
## $number.of.items
## [1] 3
##
## $alpha
## [1] 0.8563767
```

```r
cronbach(study2_FYE[, c(162:164)]) #Phys Int --> 0.90
```

```
## $sample.size
## [1] 551
##
## $number.of.items
## [1] 3
##
## $alpha
## [1] 0.8961257
```

```r
cronbach(study2_FYE[, c(165:168)]) #Phys PC --> 0.93

## $sample.size
## [1] 546
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.9373323

cronbach(study2_FYE[, c(171, 173:175)]) #Math Rec --> 0.86

## $sample.size
## [1] 525
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.8481087

cronbach(study2_FYE[, c(176:178)]) #Math Int --> 0.88

## $sample.size
## [1] 552
##
## $number.of.items
## [1] 3
##
## $alpha
## [1] 0.8748042

cronbach(study2_FYE[, c(179:182)]) #Math PC --> 0.92

## $sample.size
## [1] 553
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.9159053

cronbach(study2_FYE[, c(73:77)]) #Eng Agency --> 0.92

## $sample.size
## [1] 570
##
## $number.of.items
## [1] 5
##
```

```
## $alpha
## [1] 0.9190039

cronbach(study2_FYE[, c(119,122:124,127)]) #Personal Agency Intent --> 0.89

## $sample.size
## [1] 563
##
## $number.of.items
## [1] 5
##
## $alpha
## [1] 0.8942381

cronbach(study2_FYE[, c(129:132)]) #Personal Agency Forethought --> 0.87

## $sample.size
## [1] 568
##
## $number.of.items
## [1] 4
##
## $alpha
## [1] 0.8644832

cfa_fgcs <- '
erec =~ Q3Eng_f + Q3Eng_e + Q3Eng_c + Q3Eng_d
eint =~ Q3Eng_h  + Q3Eng_j + Q3Eng_i
epc =~ Q3Eng_k + Q3Eng_l + Q3Eng_m + Q3Eng_n

prec =~ Q12Phys_c + Q12Phys_d  + Q12Phys_a + Q12Phys_m
pint =~ Q12Phys_f + Q12Phys_g + Q12Phys_h
ppc =~ Q12Phys_i + Q12Phys_j + Q12Phys_k + Q12Phys_l

mint =~ Q12Math_f + Q12Math_g + Q12Math_h
mrec =~ Q12Math_d + Q12Math_e  + Q12Math_a + Q12Math_m  # Q12Math_c
mpc =~ Q12Math_i + Q12Math_j + Q12Math_k + Q12Math_l


intent =~ Q8f + Q8e + Q8g + Q8j + Q8b
fore =~ Q8o + Q8n + Q8m + Q8l

engID =~  eint + epc + erec
physID =~ prec + pint + ppc
mathID =~ mint + mrec + mpc

engagency =~ Q5c + Q5d + Q5e + Q5f + Q5g

agency =~ fore + intent
'
fit_cfa <- cfa(cfa_fgcs, data = study2_FYE, std.lv = TRUE,
```

```
     test = "satorra.bentler", missing = "listwise", estimator = "MLM")

reliability(fit_cfa)

##             erec      eint       epc      prec      pint       ppc
## alpha  0.8248684 0.9113831 0.8968102 0.8624637 0.8992963 0.9387583
## omega  0.8267711 0.9142910 0.8973383 0.8663336 0.9066211 0.9388193
## omega2 0.8267711 0.9142910 0.8973383 0.8663336 0.9066211 0.9388193
## omega3 0.8280230 0.9144385 0.8975653 0.8683937 0.9101004 0.9387784
## avevar 0.5450588 0.7815484 0.6863472 0.6206048 0.7659315 0.7932694
##             mint      mrec       mpc    intent      fore engagency
## alpha  0.8820556 0.8492144 0.9249648 0.9030722 0.8784748 0.9166242
## omega  0.8836489 0.8466694 0.9244251 0.9038353 0.8774792 0.9185567
## omega2 0.8836489 0.8466694 0.9244251 0.9038353 0.8774792 0.9185567
## omega3 0.8845662 0.8408649 0.9231038 0.9041428 0.8754223 0.9204952
## avevar 0.7172759 0.5806003 0.7535987 0.6533950 0.6416953 0.6939821
##            total
## alpha  0.9546412
## omega  0.9786946
## omega2 0.9786946
## omega3 0.9728964
## avevar 0.6774929


fit_cfa <- cfa(cfa_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
               missing = "listwise", estimator = "MLM")
summary(fit_cfa, fit.measures = T, standardized = T, modindices = F, rsq = T)


## lavaan 0.6-3 ended normally after 124 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                        115
##
##                                                   Used       Total
##   Number of observations                           456         595
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                    2604.012    1874.231
##   Degrees of freedom                              1013        1013
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.389
##     for the Satorra-Bentler correction
##
## Model test baseline model:
##
##   Minimum Function Test Statistic            18506.846   13812.069
##   Degrees of freedom                              1081        1081
```

```
##   P-value                                       0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                   0.909       0.932
##   Tucker-Lewis Index (TLI)                      0.903       0.928
##
##   Robust Comparative Fit Index (CFI)                        0.930
##   Robust Tucker-Lewis Index (TLI)                           0.925
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)            -29561.866  -29561.866
##   Loglikelihood unrestricted model (H1)    -28259.860  -28259.860
##
##   Number of free parameters                       115         115
##   Akaike (AIC)                              59353.732   59353.732
##   Bayesian (BIC)                            59827.818   59827.818
##   Sample-size adjusted Bayesian (BIC)       59462.846   59462.846
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                         0.059       0.043
##   90 Percent Confidence Interval          0.056  0.061       0.041  0.046
##   P-value RMSEA <= 0.05                         0.000       1.000
##
##   Robust RMSEA                                              0.051
##   90 Percent Confidence Interval                            0.047  0.054
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                          0.053       0.053
##
## Parameter Estimates:
##
##   Information                                Expected
##   Information saturated (h1) model          Structured
##   Standard Errors                           Robust.sem
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f           0.994    0.067   14.858    0.000    1.315    0.821
##     Q3Eng_e           0.869    0.067   13.052    0.000    1.150    0.734
##     Q3Eng_c           0.901    0.067   13.504    0.000    1.192    0.711
##     Q3Eng_d           0.840    0.071   11.769    0.000    1.111    0.684
##   eint =~
##     Q3Eng_h           0.462    0.048    9.599    0.000    0.952    0.841
##     Q3Eng_j           0.556    0.050   11.022    0.000    1.146    0.886
##     Q3Eng_i           0.537    0.051   10.593    0.000    1.107    0.919
```

```
##   epc =~
##     Q3Eng_k           0.577    0.060    9.673    0.000    1.130    0.872
##     Q3Eng_l           0.564    0.059    9.642    0.000    1.106    0.816
##     Q3Eng_m           0.588    0.059    9.963    0.000    1.152    0.808
##     Q3Eng_n           0.531    0.056    9.497    0.000    1.041    0.821
##   prec =~
##     Q12Phys_c         0.490    0.049   10.079    0.000    1.096    0.744
##     Q12Phys_d         0.616    0.057   10.817    0.000    1.376    0.821
##     Q12Phys_a         0.586    0.056   10.534    0.000    1.309    0.800
##     Q12Phys_m         0.641    0.059   10.849    0.000    1.431    0.776
##   pint =~
##     Q12Phys_f         0.568    0.054   10.433    0.000    1.224    0.815
##     Q12Phys_g         0.729    0.064   11.403    0.000    1.571    0.937
##     Q12Phys_h         0.701    0.063   11.054    0.000    1.510    0.859
##   ppc =~
##     Q12Phys_i         0.389    0.077    5.072    0.000    1.426    0.908
##     Q12Phys_j         0.374    0.074    5.035    0.000    1.370    0.878
##     Q12Phys_k         0.388    0.075    5.139    0.000    1.421    0.879
##     Q12Phys_l         0.381    0.074    5.143    0.000    1.396    0.898
##   mint =~
##     Q12Math_f         0.663    0.066   10.000    0.000    1.212    0.814
##     Q12Math_g         0.739    0.068   10.800    0.000    1.350    0.914
##     Q12Math_h         0.682    0.062   10.936    0.000    1.246    0.812
##   mrec =~
##     Q12Math_d         0.354    0.072    4.924    0.000    1.141    0.748
##     Q12Math_e         0.343    0.069    4.963    0.000    1.103    0.741
##     Q12Math_a         0.348    0.071    4.933    0.000    1.122    0.818
##     Q12Math_m         0.391    0.079    4.941    0.000    1.261    0.750
##   mpc =~
##     Q12Math_i         0.343    0.074    4.660    0.000    1.206    0.882
##     Q12Math_j         0.342    0.074    4.620    0.000    1.205    0.868
##     Q12Math_k         0.344    0.073    4.716    0.000    1.211    0.838
##     Q12Math_l         0.334    0.069    4.859    0.000    1.174    0.888
##   intent =~
##     Q8f               0.658    0.074    8.934    0.000    1.150    0.825
##     Q8e               0.603    0.067    9.069    0.000    1.055    0.825
##     Q8g               0.614    0.069    8.853    0.000    1.074    0.798
##     Q8j               0.647    0.071    9.111    0.000    1.131    0.811
##     Q8b               0.565    0.067    8.459    0.000    0.988    0.778
##   fore =~
##     Q8o               0.495    0.052    9.470    0.000    0.955    0.819
##     Q8n               0.514    0.053    9.689    0.000    0.993    0.849
##     Q8m               0.498    0.055    9.139    0.000    0.962    0.735
##     Q8l               0.495    0.051    9.759    0.000    0.957    0.813
##   engID =~
##     eint              1.804    0.203    8.898    0.000    0.875    0.875
##     epc               1.685    0.229    7.364    0.000    0.860    0.860
##     erec              0.866    0.100    8.615    0.000    0.655    0.655
##   physID =~
##     prec              1.998    0.224    8.932    0.000    0.894    0.894
```

```
##     pint              1.908    0.210    9.071    0.000    0.886    0.886
##     ppc               3.527    0.740    4.763    0.000    0.962    0.962
##   mathID =~
##     mint              1.531    0.182    8.411    0.000    0.837    0.837
##     mrec              3.062    0.670    4.568    0.000    0.951    0.951
##     mpc               3.376    0.766    4.404    0.000    0.959    0.959
##   engagency =~
##     Q5c               0.925    0.053   17.442    0.000    0.925    0.858
##     Q5d               0.756    0.060   12.501    0.000    0.756    0.778
##     Q5e               0.880    0.052   16.848    0.000    0.880    0.874
##     Q5f               0.920    0.059   15.520    0.000    0.920    0.787
##     Q5g               0.923    0.057   16.247    0.000    0.923    0.866
##   agency =~
##     fore              1.653    0.222    7.435    0.000    0.856    0.856
##     intent            1.434    0.200    7.184    0.000    0.820    0.820
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~~
##     physID            0.550    0.042   13.078    0.000    0.550    0.550
##     mathID            0.513    0.048   10.736    0.000    0.513    0.513
##     engagency         0.647    0.046   14.126    0.000    0.647    0.647
##     agency            0.643    0.058   11.046    0.000    0.643    0.643
##   physID ~~
##     mathID            0.413    0.052    8.025    0.000    0.413    0.413
##     engagency         0.375    0.051    7.390    0.000    0.375    0.375
##     agency            0.327    0.058    5.664    0.000    0.327    0.327
##   mathID ~~
##     engagency         0.397    0.046    8.590    0.000    0.397    0.397
##     agency            0.413    0.058    7.133    0.000    0.413    0.413
##   engagency ~~
##     agency            0.622    0.054   11.547    0.000    0.622    0.622
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f           0.839    0.114    7.383    0.000    0.839    0.327
##    .Q3Eng_e           1.134    0.118    9.576    0.000    1.134    0.462
##    .Q3Eng_c           1.389    0.148    9.369    0.000    1.389    0.494
##    .Q3Eng_d           1.402    0.149    9.419    0.000    1.402    0.532
##    .Q3Eng_h           0.376    0.061    6.203    0.000    0.376    0.293
##    .Q3Eng_j           0.360    0.054    6.666    0.000    0.360    0.215
##    .Q3Eng_i           0.226    0.056    4.033    0.000    0.226    0.156
##    .Q3Eng_k           0.404    0.049    8.202    0.000    0.404    0.240
##    .Q3Eng_l           0.613    0.085    7.240    0.000    0.613    0.334
##    .Q3Eng_m           0.703    0.063   11.157    0.000    0.703    0.347
##    .Q3Eng_n           0.524    0.074    7.056    0.000    0.524    0.326
##    .Q12Phys_c         0.967    0.086   11.306    0.000    0.967    0.446
##    .Q12Phys_d         0.914    0.097    9.383    0.000    0.914    0.326
##    .Q12Phys_a         0.961    0.105    9.183    0.000    0.961    0.359
##    .Q12Phys_m         1.350    0.133   10.123    0.000    1.350    0.397
```

```
##    .Q12Phys_f         0.756    0.085    8.890    0.000    0.756    0.335
##    .Q12Phys_g         0.340    0.054    6.299    0.000    0.340    0.121
##    .Q12Phys_h         0.812    0.124    6.552    0.000    0.812    0.263
##    .Q12Phys_i         0.431    0.050    8.532    0.000    0.431    0.175
##    .Q12Phys_j         0.560    0.063    8.955    0.000    0.560    0.230
##    .Q12Phys_k         0.593    0.061    9.653    0.000    0.593    0.227
##    .Q12Phys_l         0.469    0.058    8.136    0.000    0.469    0.194
##    .Q12Math_f         0.746    0.087    8.627    0.000    0.746    0.337
##    .Q12Math_g         0.358    0.061    5.829    0.000    0.358    0.164
##    .Q12Math_h         0.805    0.098    8.223    0.000    0.805    0.341
##    .Q12Math_d         1.024    0.117    8.777    0.000    1.024    0.440
##    .Q12Math_e         0.999    0.121    8.280    0.000    0.999    0.451
##    .Q12Math_a         0.621    0.072    8.580    0.000    0.621    0.330
##    .Q12Math_m         1.232    0.172    7.159    0.000    1.232    0.437
##    .Q12Math_i         0.415    0.056    7.457    0.000    0.415    0.222
##    .Q12Math_j         0.477    0.054    8.806    0.000    0.477    0.247
##    .Q12Math_k         0.621    0.082    7.526    0.000    0.621    0.297
##    .Q12Math_l         0.369    0.060    6.150    0.000    0.369    0.211
##    .Q8f               0.621    0.081    7.628    0.000    0.621    0.319
##    .Q8e               0.522    0.061    8.519    0.000    0.522    0.320
##    .Q8g               0.658    0.068    9.717    0.000    0.658    0.363
##    .Q8j               0.665    0.080    8.333    0.000    0.665    0.342
##    .Q8b               0.636    0.094    6.784    0.000    0.636    0.394
##    .Q8o               0.449    0.057    7.806    0.000    0.449    0.330
##    .Q8n               0.381    0.061    6.287    0.000    0.381    0.279
##    .Q8m               0.788    0.106    7.415    0.000    0.788    0.460
##    .Q8l               0.469    0.059    7.951    0.000    0.469    0.339
##    .Q5c               0.306    0.041    7.497    0.000    0.306    0.264
##    .Q5d               0.372    0.068    5.459    0.000    0.372    0.394
##    .Q5e               0.239    0.032    7.398    0.000    0.239    0.236
##    .Q5f               0.519    0.106    4.886    0.000    0.519    0.380
##    .Q5g               0.283    0.049    5.760    0.000    0.283    0.249
##     erec              1.000                               0.572    0.572
##     eint              1.000                               0.235    0.235
##     epc               1.000                               0.260    0.260
##     prec              1.000                               0.200    0.200
##     pint              1.000                               0.215    0.215
##     ppc               1.000                               0.074    0.074
##     mint              1.000                               0.299    0.299
##     mrec              1.000                               0.096    0.096
##     mpc               1.000                               0.081    0.081
##     intent            1.000                               0.327    0.327
##     fore              1.000                               0.268    0.268
##     engID             1.000                               1.000    1.000
##     physID            1.000                               1.000    1.000
##     mathID            1.000                               1.000    1.000
##     engagency         1.000                               1.000    1.000
##     agency            1.000                               1.000    1.000
##
## R-Square:
```

```
##                   Estimate
##     Q3Eng_f         0.673
##     Q3Eng_e         0.538
##     Q3Eng_c         0.506
##     Q3Eng_d         0.468
##     Q3Eng_h         0.707
##     Q3Eng_j         0.785
##     Q3Eng_i         0.844
##     Q3Eng_k         0.760
##     Q3Eng_l         0.666
##     Q3Eng_m         0.653
##     Q3Eng_n         0.674
##     Q12Phys_c       0.554
##     Q12Phys_d       0.674
##     Q12Phys_a       0.641
##     Q12Phys_m       0.603
##     Q12Phys_f       0.665
##     Q12Phys_g       0.879
##     Q12Phys_h       0.737
##     Q12Phys_i       0.825
##     Q12Phys_j       0.770
##     Q12Phys_k       0.773
##     Q12Phys_l       0.806
##     Q12Math_f       0.663
##     Q12Math_g       0.836
##     Q12Math_h       0.659
##     Q12Math_d       0.560
##     Q12Math_e       0.549
##     Q12Math_a       0.670
##     Q12Math_m       0.563
##     Q12Math_i       0.778
##     Q12Math_j       0.753
##     Q12Math_k       0.703
##     Q12Math_l       0.789
##     Q8f             0.681
##     Q8e             0.680
##     Q8g             0.637
##     Q8j             0.658
##     Q8b             0.606
##     Q8o             0.670
##     Q8n             0.721
##     Q8m             0.540
##     Q8l             0.661
##     Q5c             0.736
##     Q5d             0.606
##     Q5e             0.764
##     Q5f             0.620
##     Q5g             0.751
##     erec            0.428
##     eint            0.765
```

```
##     epc                  0.740
##     prec                 0.800
##     pint                 0.785
##     ppc                  0.926
##     mint                 0.701
##     mrec                 0.904
##     mpc                  0.919
##     intent               0.673
##     fore                 0.732
```

```
full_fgcs <- '
erec =~ Q3Eng_f + Q3Eng_e + Q3Eng_c + Q3Eng_d
eint =~ Q3Eng_h  + Q3Eng_j + Q3Eng_i
epc =~ Q3Eng_k + Q3Eng_l + Q3Eng_m + Q3Eng_n

prec =~ Q12Phys_c + Q12Phys_d  + Q12Phys_a + Q12Phys_m
pint =~ Q12Phys_f + Q12Phys_g + Q12Phys_h
ppc =~ Q12Phys_i + Q12Phys_j + Q12Phys_k + Q12Phys_l

mint =~ Q12Math_f + Q12Math_g + Q12Math_h
mrec =~ Q12Math_d + Q12Math_e  + Q12Math_a + Q12Math_m  # Q12Math_c
mpc =~ Q12Math_i + Q12Math_j + Q12Math_k + Q12Math_l


intent =~ Q8f + Q8e + Q8g + Q8j + Q8b
fore =~ Q8o + Q8n + Q8m + Q8l

engID =~  eint + epc + erec
physID =~ prec + pint + ppc
mathID =~ mint + mrec + mpc

engagency =~ Q5c + Q5d + Q5e + Q5g + Q5f

agency =~ fore + intent

engID ~  i*engagency + a*agency
physID ~ b*agency
mathID ~ c*agency
engagency ~ f*agency + e*mathID + d*physID

engID ~ g*physID + h*mathID
physID ~ a*mathID

#indirect effect
ind1 := c*a*g
ind3 := c*h
```

```
ind4 := b*g
total := a + i
'

##without group = () function
fit <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE,

      test = "satorra.bentler", missing = "listwise", estimator = "MLM")
summary(fit, fit.measures = T, standardized = T, modindices = F, rsq = T)
```

```
## lavaan 0.6-3 ended normally after 125 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                        115
##   Number of equality constraints                     1
##
##                                                   Used       Total
##   Number of observations                           456         595
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                    2605.646    1873.989
##   Degrees of freedom                              1014        1014
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.390
##     for the Satorra-Bentler correction
##
## Model test baseline model:
##
##   Minimum Function Test Statistic            18506.846   13812.069
##   Degrees of freedom                              1081        1081
##   P-value                                        0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                    0.909       0.932
##   Tucker-Lewis Index (TLI)                       0.903       0.928
##
##   Robust Comparative Fit Index (CFI)                         0.930
##   Robust Tucker-Lewis Index (TLI)                            0.925
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)             -29562.683  -29562.683
##   Loglikelihood unrestricted model (H1)     -28259.860  -28259.860
##
##   Number of free parameters                        114         114
##   Akaike (AIC)                               59353.366   59353.366
```

```
##   Bayesian (BIC)                              59823.330   59823.330
##   Sample-size adjusted Bayesian (BIC)         59461.531   59461.531
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                           0.059       0.043
##   90 Percent Confidence Interval          0.056  0.061       0.041  0.046
##   P-value RMSEA <= 0.05                           0.000       1.000
##
##   Robust RMSEA                                                0.051
##   90 Percent Confidence Interval                              0.047  0.054
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                            0.053       0.053
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard Errors                           Robust.sem
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f           0.995    0.067   14.850    0.000    1.315    0.821
##     Q3Eng_e           0.870    0.067   13.039    0.000    1.149    0.734
##     Q3Eng_c           0.901    0.067   13.478    0.000    1.191    0.711
##     Q3Eng_d           0.840    0.072   11.753    0.000    1.111    0.684
##   eint =~
##     Q3Eng_h           0.465    0.048    9.616    0.000    0.951    0.840
##     Q3Eng_j           0.560    0.050   11.099    0.000    1.144    0.885
##     Q3Eng_i           0.541    0.051   10.658    0.000    1.106    0.919
##   epc =~
##     Q3Eng_k           0.570    0.060    9.438    0.000    1.129    0.872
##     Q3Eng_l           0.557    0.059    9.407    0.000    1.105    0.816
##     Q3Eng_m           0.580    0.060    9.715    0.000    1.150    0.808
##     Q3Eng_n           0.524    0.057    9.260    0.000    1.040    0.820
##   prec =~
##     Q12Phys_c         0.491    0.049   10.111    0.000    1.099    0.745
##     Q12Phys_d         0.616    0.057   10.844    0.000    1.380    0.822
##     Q12Phys_a         0.586    0.055   10.567    0.000    1.313    0.801
##     Q12Phys_m         0.641    0.059   10.891    0.000    1.435    0.777
##   pint =~
##     Q12Phys_f         0.569    0.054   10.475    0.000    1.227    0.816
##     Q12Phys_g         0.730    0.064   11.444    0.000    1.575    0.938
##     Q12Phys_h         0.702    0.063   11.095    0.000    1.514    0.859
##   ppc =~
##     Q12Phys_i         0.388    0.077    5.075    0.000    1.430    0.909
##     Q12Phys_j         0.373    0.074    5.039    0.000    1.375    0.878
```

```
##     Q12Phys_k          0.387    0.075    5.143    0.000    1.426    0.880
##     Q12Phys_l          0.380    0.074    5.147    0.000    1.401    0.898
##   mint =~
##     Q12Math_f          0.663    0.066   10.024    0.000    1.214    0.815
##     Q12Math_g          0.739    0.068   10.829    0.000    1.353    0.915
##     Q12Math_h          0.682    0.062   10.963    0.000    1.249    0.812
##   mrec =~
##     Q12Math_d          0.357    0.071    4.997    0.000    1.145    0.749
##     Q12Math_e          0.345    0.069    5.039    0.000    1.106    0.742
##     Q12Math_a          0.351    0.070    5.007    0.000    1.125    0.819
##     Q12Math_m          0.394    0.079    5.017    0.000    1.264    0.751
##   mpc =~
##     Q12Math_i          0.340    0.074    4.609    0.000    1.209    0.883
##     Q12Math_j          0.340    0.074    4.572    0.000    1.209    0.868
##     Q12Math_k          0.341    0.073    4.665    0.000    1.214    0.839
##     Q12Math_l          0.331    0.069    4.804    0.000    1.178    0.889
##   intent =~
##     Q8f                0.662    0.075    8.850    0.000    1.147    0.825
##     Q8e                0.607    0.067    9.000    0.000    1.052    0.824
##     Q8g                0.618    0.071    8.765    0.000    1.071    0.797
##     Q8j                0.651    0.072    9.044    0.000    1.128    0.810
##     Q8b                0.569    0.068    8.414    0.000    0.985    0.777
##   fore =~
##     Q8o                0.483    0.055    8.860    0.000    0.952    0.817
##     Q8n                0.503    0.055    9.092    0.000    0.990    0.849
##     Q8m                0.487    0.056    8.638    0.000    0.959    0.734
##     Q8l                0.484    0.053    9.131    0.000    0.954    0.812
##   engID =~
##     eint               1.127    0.143    7.890    0.000    0.872    0.872
##     epc                1.082    0.169    6.419    0.000    0.864    0.864
##     erec               0.546    0.069    7.864    0.000    0.654    0.654
##   physID =~
##     prec               1.775    0.198    8.975    0.000    0.895    0.895
##     pint               1.693    0.190    8.934    0.000    0.886    0.886
##     ppc                3.139    0.662    4.742    0.000    0.962    0.962
##   mathID =~
##     mint               1.401    0.173    8.084    0.000    0.838    0.838
##     mrec               2.784    0.607    4.589    0.000    0.950    0.950
##     mpc                3.121    0.723    4.317    0.000    0.960    0.960
##   engagency =~
##     Q5c                0.699    0.055   12.729    0.000    0.924    0.858
##     Q5d                0.572    0.041   13.911    0.000    0.755    0.778
##     Q5e                0.664    0.054   12.225    0.000    0.878    0.873
##     Q5g                0.697    0.058   12.114    0.000    0.921    0.866
##     Q5f                0.696    0.061   11.474    0.000    0.920    0.787
##   agency =~
##     fore               1.696    0.241    7.041    0.000    0.861    0.861
##     intent             1.414    0.201    7.040    0.000    0.816    0.816
##
## Regressions:
```

```
##                          Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)          0.391    0.104    3.750    0.000    0.327    0.327
##     agency     (a)          0.378    0.067    5.667    0.000    0.239    0.239
##   physID ~
##     agency     (b)          0.196    0.067    2.906    0.004    0.173    0.173
##   mathID ~
##     agency     (c)          0.443    0.074    5.982    0.000    0.405    0.405
##   engagency ~
##     agency     (f)          0.684    0.112    6.106    0.000    0.518    0.518
##     mathID     (e)          0.146    0.066    2.212    0.027    0.121    0.121
##     physID     (d)          0.184    0.079    2.332    0.020    0.158    0.158
##   engID ~
##     physID     (g)          0.395    0.077    5.150    0.000    0.281    0.281
##     mathID     (h)          0.248    0.086    2.886    0.004    0.171    0.171
##   physID ~
##     mathID     (a)          0.378    0.067    5.667    0.000    0.366    0.366
##
## Variances:
##                          Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f                 0.838    0.113    7.382    0.000    0.838    0.326
##    .Q3Eng_e                 1.134    0.118    9.572    0.000    1.134    0.462
##    .Q3Eng_c                 1.390    0.148    9.377    0.000    1.390    0.495
##    .Q3Eng_d                 1.403    0.149    9.424    0.000    1.403    0.532
##    .Q3Eng_h                 0.376    0.061    6.197    0.000    0.376    0.294
##    .Q3Eng_j                 0.361    0.054    6.667    0.000    0.361    0.216
##    .Q3Eng_i                 0.226    0.056    4.025    0.000    0.226    0.156
##    .Q3Eng_k                 0.402    0.049    8.179    0.000    0.402    0.240
##    .Q3Eng_l                 0.613    0.085    7.232    0.000    0.613    0.334
##    .Q3Eng_m                 0.704    0.063   11.188    0.000    0.704    0.347
##    .Q3Eng_n                 0.525    0.074    7.066    0.000    0.525    0.327
##    .Q12Phys_c               0.967    0.086   11.304    0.000    0.967    0.445
##    .Q12Phys_d               0.914    0.097    9.385    0.000    0.914    0.324
##    .Q12Phys_a               0.961    0.105    9.193    0.000    0.961    0.358
##    .Q12Phys_m               1.350    0.133   10.127    0.000    1.350    0.396
##    .Q12Phys_f               0.756    0.085    8.891    0.000    0.756    0.334
##    .Q12Phys_g               0.340    0.054    6.305    0.000    0.340    0.121
##    .Q12Phys_h               0.812    0.124    6.554    0.000    0.812    0.262
##    .Q12Phys_i               0.431    0.050    8.534    0.000    0.431    0.174
##    .Q12Phys_j               0.560    0.063    8.960    0.000    0.560    0.229
##    .Q12Phys_k               0.593    0.061    9.656    0.000    0.593    0.226
##    .Q12Phys_l               0.469    0.058    8.140    0.000    0.469    0.193
##    .Q12Math_f               0.746    0.087    8.627    0.000    0.746    0.336
##    .Q12Math_g               0.358    0.061    5.831    0.000    0.358    0.164
##    .Q12Math_h               0.805    0.098    8.225    0.000    0.805    0.340
##    .Q12Math_d               1.023    0.117    8.771    0.000    1.023    0.439
##    .Q12Math_e               0.999    0.121    8.281    0.000    0.999    0.449
##    .Q12Math_a               0.622    0.072    8.589    0.000    0.622    0.330
##    .Q12Math_m               1.232    0.172    7.160    0.000    1.232    0.435
##    .Q12Math_i               0.415    0.056    7.461    0.000    0.415    0.221
```

```
##    .Q12Math_j          0.477    0.054    8.810    0.000    0.477    0.246
##    .Q12Math_k          0.621    0.082    7.532    0.000    0.621    0.296
##    .Q12Math_l          0.369    0.060    6.152    0.000    0.369    0.210
##    .Q8f                0.620    0.081    7.649    0.000    0.620    0.320
##    .Q8e                0.522    0.061    8.525    0.000    0.522    0.321
##    .Q8g                0.658    0.068    9.693    0.000    0.658    0.365
##    .Q8j                0.665    0.080    8.353    0.000    0.665    0.343
##    .Q8b                0.637    0.094    6.790    0.000    0.637    0.396
##    .Q8o                0.450    0.058    7.801    0.000    0.450    0.332
##    .Q8n                0.381    0.060    6.323    0.000    0.381    0.280
##    .Q8m                0.788    0.106    7.410    0.000    0.788    0.461
##    .Q8l                0.469    0.059    7.936    0.000    0.469    0.340
##    .Q5c                0.305    0.041    7.505    0.000    0.305    0.263
##    .Q5d                0.372    0.068    5.467    0.000    0.372    0.395
##    .Q5e                0.239    0.032    7.412    0.000    0.239    0.237
##    .Q5g                0.284    0.049    5.774    0.000    0.284    0.251
##    .Q5f                0.518    0.106    4.890    0.000    0.518    0.380
##     erec               1.000                               0.573    0.573
##     eint               1.000                               0.239    0.239
##     epc                1.000                               0.254    0.254
##     prec               1.000                               0.199    0.199
##     pint               1.000                               0.215    0.215
##     ppc                1.000                               0.074    0.074
##     mint               1.000                               0.299    0.299
##     mrec               1.000                               0.097    0.097
##     mpc                1.000                               0.079    0.079
##     intent             1.000                               0.333    0.333
##     fore               1.000                               0.258    0.258
##    .engID              1.000                               0.399    0.399
##    .physID             1.000                               0.784    0.784
##    .mathID             1.000                               0.836    0.836
##    .engagency          1.000                               0.573    0.573
##     agency             1.000                               1.000    1.000
##
## R-Square:
##                    Estimate
##     Q3Eng_f           0.674
##     Q3Eng_e           0.538
##     Q3Eng_c           0.505
##     Q3Eng_d           0.468
##     Q3Eng_h           0.706
##     Q3Eng_j           0.784
##     Q3Eng_i           0.844
##     Q3Eng_k           0.760
##     Q3Eng_l           0.666
##     Q3Eng_m           0.653
##     Q3Eng_n           0.673
##     Q12Phys_c         0.555
##     Q12Phys_d         0.676
##     Q12Phys_a         0.642
```

```
##     Q12Phys_m         0.604
##     Q12Phys_f         0.666
##     Q12Phys_g         0.879
##     Q12Phys_h         0.738
##     Q12Phys_i         0.826
##     Q12Phys_j         0.771
##     Q12Phys_k         0.774
##     Q12Phys_l         0.807
##     Q12Math_f         0.664
##     Q12Math_g         0.836
##     Q12Math_h         0.660
##     Q12Math_d         0.561
##     Q12Math_e         0.551
##     Q12Math_a         0.670
##     Q12Math_m         0.565
##     Q12Math_i         0.779
##     Q12Math_j         0.754
##     Q12Math_k         0.704
##     Q12Math_l         0.790
##     Q8f               0.680
##     Q8e               0.679
##     Q8g               0.635
##     Q8j               0.657
##     Q8b               0.604
##     Q8o               0.668
##     Q8n               0.720
##     Q8m               0.539
##     Q8l               0.660
##     Q5c               0.737
##     Q5d               0.605
##     Q5e               0.763
##     Q5g               0.749
##     Q5f               0.620
##     erec              0.427
##     eint              0.761
##     epc               0.746
##     prec              0.801
##     pint              0.785
##     ppc               0.926
##     mint              0.701
##     mrec              0.903
##     mpc               0.921
##     intent            0.667
##     fore              0.742
##     engID             0.601
##     physID            0.216
##     mathID            0.164
##     engagency         0.427
##
## Defined Parameters:
```

```
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     ind1             0.066    0.018    3.763    0.000    0.027    0.027
##     ind3             0.110    0.039    2.789    0.005    0.069    0.069
##     ind4             0.077    0.030    2.611    0.009    0.049    0.049
##     total            0.769    0.098    7.865    0.000    0.565    0.565
```

```
#Model 1: configural invariance (measurement structure):
fit1 <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
            missing = "listwise", estimator = "MLM", group = "Q31b")
summary(fit1, fit.measures = T, standardized = T, modindices = F, rsq = T)
```

```
## lavaan 0.6-3 ended normally after 181 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                        324
##   Number of equality constraints                     1
##
##                                                   Used       Total
##   Number of observations per group
##   1                                                342         455
##   0                                                114         140
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                    4115.296    3062.345
##   Degrees of freedom                              2027        2027
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.344
##     for the Satorra-Bentler correction
##
## Chi-square for each group:
##
##   1                                           2327.505    1731.983
##   0                                           1787.791    1330.362
##
## Model test baseline model:
##
##   Minimum Function Test Statistic            20216.072   14956.847
##   Degrees of freedom                              2162        2162
##   P-value                                        0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                    0.884       0.919
##   Tucker-Lewis Index (TLI)                       0.877       0.914
##
##   Robust Comparative Fit Index (CFI)                         0.920
##   Robust Tucker-Lewis Index (TLI)                            0.914
```

```
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)             -29364.784  -29364.784
##   Loglikelihood unrestricted model (H1)     -27307.137  -27307.137
##
##   Number of free parameters                        323         323
##   Akaike (AIC)                               59375.569   59375.569
##   Bayesian (BIC)                             60707.134   60707.134
##   Sample-size adjusted Bayesian (BIC)        59682.036   59682.036
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.067       0.047
##   90 Percent Confidence Interval          0.064  0.070       0.044  0.050
##   P-value RMSEA <= 0.05                          0.000       0.934
##
##   Robust RMSEA                                               0.055
##   90 Percent Confidence Interval                             0.051  0.059
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.059       0.059
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard Errors                           Robust.sem
##
##
## Group 1 [1]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f           0.979    0.076   12.905    0.000    1.266    0.785
##     Q3Eng_e           0.864    0.078   11.147    0.000    1.117    0.706
##     Q3Eng_c           0.980    0.080   12.195    0.000    1.266    0.739
##     Q3Eng_d           0.862    0.082   10.562    0.000    1.114    0.685
##   eint =~
##     Q3Eng_h           0.444    0.056    7.966    0.000    1.006    0.847
##     Q3Eng_j           0.517    0.057    9.106    0.000    1.170    0.891
##     Q3Eng_i           0.494    0.057    8.730    0.000    1.119    0.917
##   epc =~
##     Q3Eng_k           0.568    0.074    7.624    0.000    1.143    0.874
##     Q3Eng_l           0.556    0.072    7.667    0.000    1.119    0.826
##     Q3Eng_m           0.606    0.077    7.840    0.000    1.220    0.829
##     Q3Eng_n           0.526    0.071    7.448    0.000    1.059    0.816
##   prec =~
```

```
##     Q12Phys_c          0.485    0.056    8.732    0.000    1.066    0.747
##     Q12Phys_d          0.603    0.065    9.225    0.000    1.325    0.801
##     Q12Phys_a          0.595    0.065    9.088    0.000    1.308    0.797
##     Q12Phys_m          0.654    0.069    9.442    0.000    1.438    0.786
##   pint =~
##     Q12Phys_f          0.599    0.065    9.234    0.000    1.287    0.850
##     Q12Phys_g          0.734    0.074    9.860    0.000    1.577    0.941
##     Q12Phys_h          0.721    0.075    9.582    0.000    1.550    0.884
##   ppc =~
##     Q12Phys_i          0.329    0.103    3.207    0.001    1.444    0.911
##     Q12Phys_j          0.324    0.101    3.204    0.001    1.419    0.887
##     Q12Phys_k          0.335    0.103    3.255    0.001    1.468    0.894
##     Q12Phys_l          0.320    0.098    3.254    0.001    1.403    0.899
##   mint =~
##     Q12Math_f          0.688    0.076    9.044    0.000    1.256    0.822
##     Q12Math_g          0.753    0.077    9.757    0.000    1.373    0.909
##     Q12Math_h          0.673    0.067    9.987    0.000    1.227    0.805
##   mrec =~
##     Q12Math_d          0.308    0.082    3.732    0.000    1.120    0.730
##     Q12Math_e          0.298    0.079    3.768    0.000    1.087    0.721
##     Q12Math_a          0.306    0.082    3.719    0.000    1.116    0.809
##     Q12Math_m          0.352    0.094    3.754    0.000    1.280    0.745
##   mpc =~
##     Q12Math_i          0.303    0.087    3.479    0.001    1.216    0.884
##     Q12Math_j          0.308    0.091    3.380    0.001    1.236    0.867
##     Q12Math_k          0.308    0.088    3.506    0.000    1.238    0.832
##     Q12Math_l          0.294    0.082    3.592    0.000    1.181    0.875
##   intent =~
##     Q8f                0.692    0.089    7.814    0.000    1.157    0.811
##     Q8e                0.632    0.078    8.074    0.000    1.056    0.817
##     Q8g                0.650    0.083    7.812    0.000    1.086    0.792
##     Q8j                0.673    0.084    7.970    0.000    1.124    0.797
##     Q8b                0.584    0.078    7.532    0.000    0.976    0.768
##   fore =~
##     Q8o                0.480    0.069    6.971    0.000    0.978    0.831
##     Q8n                0.511    0.070    7.256    0.000    1.043    0.859
##     Q8m                0.476    0.069    6.858    0.000    0.970    0.711
##     Q8l                0.463    0.064    7.249    0.000    0.944    0.796
##   engID =~
##     eint               1.245    0.198    6.281    0.000    0.897    0.897
##     epc                1.071    0.207    5.173    0.000    0.868    0.868
##     erec               0.502    0.073    6.914    0.000    0.634    0.634
##   physID =~
##     prec               1.722    0.225    7.644    0.000    0.891    0.891
##     pint               1.673    0.222    7.532    0.000    0.885    0.885
##     ppc                3.753    1.217    3.084    0.002    0.974    0.974
##   mathID =~
##     mint               1.402    0.196    7.143    0.000    0.836    0.836
##     mrec               3.217    0.905    3.555    0.000    0.962    0.962
##     mpc                3.576    1.094    3.268    0.001    0.969    0.969
```

```
##   engagency =~
##     Q5c                  0.728    0.067   10.825    0.000    0.977    0.869
##     Q5d                  0.543    0.046   11.803    0.000    0.730    0.739
##     Q5e                  0.655    0.066    9.959    0.000    0.879    0.866
##     Q5g                  0.702    0.071    9.922    0.000    0.943    0.852
##     Q5f                  0.692    0.074    9.390    0.000    0.929    0.767
##   agency =~
##     fore                 1.777    0.313    5.676    0.000    0.872    0.872
##     intent               1.338    0.218    6.131    0.000    0.801    0.801
##
## Regressions:
##                       Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)       0.418    0.129    3.239    0.001    0.344    0.344
##     agency     (a)       0.367    0.075    4.897    0.000    0.225    0.225
##   physID ~
##     agency     (b)       0.240    0.080    2.982    0.003    0.211    0.211
##   mathID ~
##     agency     (c)       0.429    0.085    5.069    0.000    0.394    0.394
##   engagency ~
##     agency     (f)       0.667    0.140    4.756    0.000    0.497    0.497
##     mathID     (e)       0.163    0.079    2.075    0.038    0.132    0.132
##     physID     (d)       0.230    0.096    2.397    0.017    0.195    0.195
##   engID ~
##     physID     (g)       0.412    0.093    4.434    0.000    0.287    0.287
##     mathID     (h)       0.253    0.104    2.428    0.015    0.169    0.169
##   physID ~
##     mathID     (a)       0.367    0.075    4.897    0.000    0.351    0.351
##
## Intercepts:
##                       Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f              3.737    0.087   42.831    0.000    3.737    2.316
##    .Q3Eng_e              3.506    0.086   40.945    0.000    3.506    2.214
##    .Q3Eng_c              4.292    0.093   46.312    0.000    4.292    2.504
##    .Q3Eng_d              4.330    0.088   49.266    0.000    4.330    2.664
##    .Q3Eng_h              5.234    0.064   81.424    0.000    5.234    4.404
##    .Q3Eng_j              4.865    0.071   68.517    0.000    4.865    3.706
##    .Q3Eng_i              5.088    0.066   77.096    0.000    5.088    4.170
##    .Q3Eng_k              4.681    0.071   66.122    0.000    4.681    3.576
##    .Q3Eng_l              4.538    0.073   61.981    0.000    4.538    3.352
##    .Q3Eng_m              4.143    0.080   52.091    0.000    4.143    2.817
##    .Q3Eng_n              4.406    0.070   62.764    0.000    4.406    3.394
##    .Q12Phys_c            3.365    0.077   43.650    0.000    3.365    2.359
##    .Q12Phys_d            3.591    0.089   40.167    0.000    3.591    2.171
##    .Q12Phys_a            3.673    0.089   41.424    0.000    3.673    2.239
##    .Q12Phys_m            3.564    0.099   36.039    0.000    3.564    1.948
##    .Q12Phys_f            4.751    0.082   58.115    0.000    4.751    3.140
##    .Q12Phys_g            4.409    0.091   48.704    0.000    4.409    2.632
##    .Q12Phys_h            4.076    0.095   43.019    0.000    4.076    2.325
##    .Q12Phys_i            4.152    0.086   48.475    0.000    4.152    2.619
```

```
##    .Q12Phys_j          4.058    0.086   46.981    0.000    4.058    2.538
##    .Q12Phys_k          3.854    0.089   43.437    0.000    3.854    2.347
##    .Q12Phys_l          4.213    0.084   49.975    0.000    4.213    2.700
##    .Q12Math_f          4.629    0.083   56.043    0.000    4.629    3.029
##    .Q12Math_g          4.471    0.082   54.775    0.000    4.471    2.960
##    .Q12Math_h          4.368    0.082   53.034    0.000    4.368    2.866
##    .Q12Math_d          4.319    0.083   52.081    0.000    4.319    2.815
##    .Q12Math_e          4.573    0.081   56.156    0.000    4.573    3.035
##    .Q12Math_a          4.520    0.075   60.669    0.000    4.520    3.279
##    .Q12Math_m          4.327    0.093   46.631    0.000    4.327    2.520
##    .Q12Math_i          4.523    0.074   60.898    0.000    4.523    3.291
##    .Q12Math_j          4.447    0.077   57.713    0.000    4.447    3.119
##    .Q12Math_k          4.333    0.080   53.900    0.000    4.333    2.913
##    .Q12Math_l          4.567    0.073   62.633    0.000    4.567    3.384
##    .Q8f                4.205    0.077   54.520    0.000    4.205    2.950
##    .Q8e                4.398    0.070   62.890    0.000    4.398    3.403
##    .Q8g                4.178    0.074   56.305    0.000    4.178    3.046
##    .Q8j                3.944    0.076   51.734    0.000    3.944    2.799
##    .Q8b                4.178    0.069   60.816    0.000    4.178    3.290
##    .Q8o                4.661    0.064   73.164    0.000    4.661    3.959
##    .Q8n                4.596    0.066   70.001    0.000    4.596    3.788
##    .Q8m                4.412    0.074   59.795    0.000    4.412    3.235
##    .Q8l                4.605    0.064   71.761    0.000    4.605    3.883
##    .Q5c                4.968    0.061   81.682    0.000    4.968    4.418
##    .Q5d                5.222    0.053   97.856    0.000    5.222    5.292
##    .Q5e                5.099    0.055   92.874    0.000    5.099    5.023
##    .Q5g                5.094    0.060   85.102    0.000    5.094    4.603
##    .Q5f                4.988    0.066   76.146    0.000    4.988    4.118
##     erec               0.000                               0.000    0.000
##     eint               0.000                               0.000    0.000
##     epc                0.000                               0.000    0.000
##     prec               0.000                               0.000    0.000
##     pint               0.000                               0.000    0.000
##     ppc                0.000                               0.000    0.000
##     mint               0.000                               0.000    0.000
##     mrec               0.000                               0.000    0.000
##     mpc                0.000                               0.000    0.000
##     intent             0.000                               0.000    0.000
##     fore               0.000                               0.000    0.000
##    .engID              0.000                               0.000    0.000
##    .physID             0.000                               0.000    0.000
##    .mathID             0.000                               0.000    0.000
##    .engagency          0.000                               0.000    0.000
##     agency             0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f            1.001    0.141    7.104    0.000    1.001    0.384
##    .Q3Eng_e            1.259    0.138    9.093    0.000    1.259    0.502
##    .Q3Eng_c            1.334    0.182    7.319    0.000    1.334    0.454
```

```
##    .Q3Eng_d          1.401    0.183    7.636    0.000    1.401    0.530
##    .Q3Eng_h          0.400    0.076    5.290    0.000    0.400    0.283
##    .Q3Eng_j          0.354    0.063    5.582    0.000    0.354    0.205
##    .Q3Eng_i          0.237    0.068    3.503    0.000    0.237    0.159
##    .Q3Eng_k          0.406    0.057    7.135    0.000    0.406    0.237
##    .Q3Eng_l          0.582    0.085    6.878    0.000    0.582    0.317
##    .Q3Eng_m          0.676    0.069    9.748    0.000    0.676    0.312
##    .Q3Eng_n          0.564    0.094    5.991    0.000    0.564    0.335
##    .Q12Phys_c        0.899    0.090    9.955    0.000    0.899    0.442
##    .Q12Phys_d        0.980    0.113    8.674    0.000    0.980    0.358
##    .Q12Phys_a        0.980    0.125    7.842    0.000    0.980    0.364
##    .Q12Phys_m        1.281    0.156    8.241    0.000    1.281    0.383
##    .Q12Phys_f        0.633    0.074    8.588    0.000    0.633    0.277
##    .Q12Phys_g        0.319    0.062    5.112    0.000    0.319    0.114
##    .Q12Phys_h        0.673    0.128    5.244    0.000    0.673    0.219
##    .Q12Phys_i        0.429    0.061    7.075    0.000    0.429    0.171
##    .Q12Phys_j        0.543    0.072    7.596    0.000    0.543    0.212
##    .Q12Phys_k        0.543    0.066    8.224    0.000    0.543    0.201
##    .Q12Phys_l        0.467    0.067    6.993    0.000    0.467    0.192
##    .Q12Math_f        0.758    0.101    7.512    0.000    0.758    0.325
##    .Q12Math_g        0.396    0.078    5.086    0.000    0.396    0.174
##    .Q12Math_h        0.816    0.113    7.235    0.000    0.816    0.351
##    .Q12Math_d        1.100    0.140    7.845    0.000    1.100    0.467
##    .Q12Math_e        1.090    0.149    7.304    0.000    1.090    0.480
##    .Q12Math_a        0.656    0.089    7.382    0.000    0.656    0.345
##    .Q12Math_m        1.311    0.213    6.156    0.000    1.311    0.444
##    .Q12Math_i        0.412    0.062    6.589    0.000    0.412    0.218
##    .Q12Math_j        0.505    0.065    7.736    0.000    0.505    0.248
##    .Q12Math_k        0.680    0.107    6.377    0.000    0.680    0.307
##    .Q12Math_l        0.427    0.076    5.657    0.000    0.427    0.235
##    .Q8f              0.694    0.105    6.605    0.000    0.694    0.342
##    .Q8e              0.556    0.077    7.251    0.000    0.556    0.333
##    .Q8g              0.701    0.085    8.270    0.000    0.701    0.373
##    .Q8j              0.723    0.101    7.162    0.000    0.723    0.364
##    .Q8b              0.660    0.118    5.584    0.000    0.660    0.410
##    .Q8o              0.429    0.066    6.496    0.000    0.429    0.309
##    .Q8n              0.385    0.068    5.648    0.000    0.385    0.262
##    .Q8m              0.919    0.137    6.690    0.000    0.919    0.494
##    .Q8l              0.516    0.071    7.283    0.000    0.516    0.367
##    .Q5c              0.310    0.047    6.572    0.000    0.310    0.245
##    .Q5d              0.442    0.083    5.314    0.000    0.442    0.453
##    .Q5e              0.257    0.039    6.536    0.000    0.257    0.250
##    .Q5g              0.336    0.065    5.197    0.000    0.336    0.275
##    .Q5f              0.603    0.135    4.460    0.000    0.603    0.411
##     erec             1.000                               0.598    0.598
##     eint             1.000                               0.195    0.195
##     epc              1.000                               0.247    0.247
##     prec             1.000                               0.207    0.207
##     pint             1.000                               0.217    0.217
##     ppc              1.000                               0.052    0.052
```

```
##     mint               1.000                                  0.301    0.301
##     mrec               1.000                                  0.075    0.075
##     mpc                1.000                                  0.062    0.062
##     intent             1.000                                  0.358    0.358
##     fore               1.000                                  0.240    0.240
##    .engID              1.000                                  0.375    0.375
##    .physID             1.000                                  0.774    0.774
##    .mathID             1.000                                  0.845    0.845
##    .engagency          1.000                                  0.555    0.555
##     agency             1.000                                  1.000    1.000
##
## R-Square:
##                     Estimate
##     Q3Eng_f            0.616
##     Q3Eng_e            0.498
##     Q3Eng_c            0.546
##     Q3Eng_d            0.470
##     Q3Eng_h            0.717
##     Q3Eng_j            0.795
##     Q3Eng_i            0.841
##     Q3Eng_k            0.763
##     Q3Eng_l            0.683
##     Q3Eng_m            0.688
##     Q3Eng_n            0.665
##     Q12Phys_c          0.558
##     Q12Phys_d          0.642
##     Q12Phys_a          0.636
##     Q12Phys_m          0.617
##     Q12Phys_f          0.723
##     Q12Phys_g          0.886
##     Q12Phys_h          0.781
##     Q12Phys_i          0.829
##     Q12Phys_j          0.788
##     Q12Phys_k          0.799
##     Q12Phys_l          0.808
##     Q12Math_f          0.675
##     Q12Math_g          0.826
##     Q12Math_h          0.649
##     Q12Math_d          0.533
##     Q12Math_e          0.520
##     Q12Math_a          0.655
##     Q12Math_m          0.556
##     Q12Math_i          0.782
##     Q12Math_j          0.752
##     Q12Math_k          0.693
##     Q12Math_l          0.765
##     Q8f                0.658
##     Q8e                0.667
##     Q8g                0.627
##     Q8j                0.636
```

```
##     Q8b                 0.590
##     Q8o                 0.691
##     Q8n                 0.738
##     Q8m                 0.506
##     Q8l                 0.633
##     Q5c                 0.755
##     Q5d                 0.547
##     Q5e                 0.750
##     Q5g                 0.725
##     Q5f                 0.589
##     erec                0.402
##     eint                0.805
##     epc                 0.753
##     prec                0.793
##     pint                0.783
##     ppc                 0.948
##     mint                0.699
##     mrec                0.925
##     mpc                 0.938
##     intent              0.642
##     fore                0.760
##     engID               0.625
##     physID              0.226
##     mathID              0.155
##     engagency           0.445
##
##
## Group 2 [0]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f           0.991    0.130    7.629    0.000    1.424    0.908
##     Q3Eng_e           0.843    0.119    7.077    0.000    1.211    0.798
##     Q3Eng_c           0.710    0.117    6.083    0.000    1.020    0.655
##     Q3Eng_d           0.801    0.145    5.505    0.000    1.150    0.711
##   eint =~
##     Q3Eng_h           0.476    0.089    5.355    0.000    0.771    0.823
##     Q3Eng_j           0.656    0.100    6.588    0.000    1.062    0.862
##     Q3Eng_i           0.668    0.100    6.675    0.000    1.081    0.934
##   epc =~
##     Q3Eng_k           0.567    0.101    5.635    0.000    1.094    0.886
##     Q3Eng_l           0.551    0.105    5.261    0.000    1.062    0.795
##     Q3Eng_m           0.478    0.081    5.910    0.000    0.922    0.723
##     Q3Eng_n           0.501    0.086    5.824    0.000    0.966    0.825
##   prec =~
##     Q12Phys_c         0.494    0.101    4.912    0.000    1.160    0.724
##     Q12Phys_d         0.668    0.112    5.975    0.000    1.568    0.901
##     Q12Phys_a         0.557    0.101    5.509    0.000    1.307    0.824
##     Q12Phys_m         0.598    0.118    5.065    0.000    1.404    0.747
```

```
##   pint =~
##     Q12Phys_f         0.495    0.097    5.104    0.000    1.052    0.717
##     Q12Phys_g         0.727    0.123    5.926    0.000    1.545    0.927
##     Q12Phys_h         0.640    0.112    5.688    0.000    1.359    0.780
##   ppc =~
##     Q12Phys_i         0.552    0.110    5.028    0.000    1.355    0.897
##     Q12Phys_j         0.490    0.103    4.753    0.000    1.203    0.845
##     Q12Phys_k         0.518    0.104    5.006    0.000    1.272    0.828
##     Q12Phys_l         0.559    0.109    5.143    0.000    1.372    0.897
##   mint =~
##     Q12Math_f         0.568    0.128    4.447    0.000    1.017    0.772
##     Q12Math_g         0.683    0.140    4.862    0.000    1.222    0.926
##     Q12Math_h         0.716    0.149    4.797    0.000    1.282    0.835
##   mrec =~
##     Q12Math_d         0.473    0.146    3.236    0.001    1.147    0.786
##     Q12Math_e         0.467    0.148    3.147    0.002    1.133    0.796
##     Q12Math_a         0.464    0.137    3.382    0.001    1.126    0.842
##     Q12Math_m         0.493    0.152    3.241    0.001    1.196    0.778
##   mpc =~
##     Q12Math_i         0.411    0.156    2.630    0.009    1.175    0.876
##     Q12Math_j         0.385    0.135    2.845    0.004    1.100    0.869
##     Q12Math_k         0.389    0.148    2.626    0.009    1.113    0.856
##     Q12Math_l         0.400    0.144    2.777    0.005    1.143    0.933
##   intent =~
##     Q8f               0.595    0.116    5.126    0.000    1.115    0.872
##     Q8e               0.542    0.114    4.761    0.000    1.015    0.836
##     Q8g               0.543    0.107    5.081    0.000    1.016    0.815
##     Q8j               0.604    0.116    5.202    0.000    1.132    0.856
##     Q8b               0.530    0.121    4.388    0.000    0.993    0.795
##   fore =~
##     Q8o               0.472    0.084    5.626    0.000    0.896    0.792
##     Q8n               0.427    0.076    5.655    0.000    0.811    0.809
##     Q8m               0.476    0.085    5.625    0.000    0.904    0.816
##     Q8l               0.522    0.090    5.778    0.000    0.991    0.870
##   engID =~
##     eint              0.777    0.157    4.968    0.000    0.787    0.787
##     epc               1.006    0.278    3.625    0.000    0.855    0.855
##     erec              0.630    0.161    3.909    0.000    0.718    0.718
##   physID =~
##     prec              1.890    0.407    4.639    0.000    0.905    0.905
##     pint              1.669    0.348    4.794    0.000    0.882    0.882
##     ppc               1.994    0.480    4.153    0.000    0.913    0.913
##   mathID =~
##     mint              1.339    0.357    3.755    0.000    0.829    0.829
##     mrec              1.993    0.765    2.605    0.009    0.911    0.911
##     mpc               2.415    1.004    2.404    0.016    0.937    0.937
##   engagency =~
##     Q5c               0.563    0.078    7.195    0.000    0.715    0.826
##     Q5d               0.658    0.076    8.626    0.000    0.836    0.912
##     Q5e               0.676    0.076    8.945    0.000    0.859    0.887
```

```
##     Q5g                 0.659    0.073    8.973    0.000    0.837    0.920
##     Q5f                 0.702    0.076    9.234    0.000    0.891    0.887
##   agency =~
##     fore                1.614    0.372    4.337    0.000    0.850    0.850
##     intent              1.584    0.376    4.213    0.000    0.846    0.846
##
## Regressions:
##                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency           0.119    0.160    0.741    0.459    0.092    0.092
##     agency              0.927    0.271    3.425    0.001    0.566    0.566
##   physID ~
##     agency              0.181    0.135    1.340    0.180    0.161    0.161
##   mathID ~
##     agency              0.478    0.156    3.063    0.002    0.432    0.432
##   engagency ~
##     agency              0.733    0.164    4.462    0.000    0.577    0.577
##     mathID              0.037    0.117    0.319    0.750    0.033    0.033
##     physID              0.075    0.118    0.639    0.523    0.067    0.067
##   engID ~
##     physID              0.259    0.130    2.001    0.045    0.178    0.178
##     mathID              0.226    0.155    1.458    0.145    0.153    0.153
##   physID ~
##     mathID              0.368    0.177    2.077    0.038    0.363    0.363
##
## Intercepts:
##                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f             3.763    0.147   25.610    0.000    3.763    2.399
##    .Q3Eng_e             3.500    0.142   24.627    0.000    3.500    2.307
##    .Q3Eng_c             4.360    0.146   29.902    0.000    4.360    2.801
##    .Q3Eng_d             4.377    0.152   28.869    0.000    4.377    2.704
##    .Q3Eng_h             5.351    0.088   61.011    0.000    5.351    5.714
##    .Q3Eng_j             4.868    0.115   42.193    0.000    4.868    3.952
##    .Q3Eng_i             5.105    0.108   47.092    0.000    5.105    4.411
##    .Q3Eng_k             4.412    0.116   38.174    0.000    4.412    3.575
##    .Q3Eng_l             4.246    0.125   33.960    0.000    4.246    3.181
##    .Q3Eng_m             4.114    0.119   34.433    0.000    4.114    3.225
##    .Q3Eng_n             4.368    0.110   39.805    0.000    4.368    3.728
##    .Q12Phys_c           3.272    0.150   21.807    0.000    3.272    2.042
##    .Q12Phys_d           3.588    0.163   22.000    0.000    3.588    2.060
##    .Q12Phys_a           3.272    0.148   22.034    0.000    3.272    2.064
##    .Q12Phys_m           3.404    0.176   19.317    0.000    3.404    1.809
##    .Q12Phys_f           4.807    0.138   34.957    0.000    4.807    3.274
##    .Q12Phys_g           4.175    0.156   26.756    0.000    4.175    2.506
##    .Q12Phys_h           3.684    0.163   22.559    0.000    3.684    2.113
##    .Q12Phys_i           3.904    0.141   27.601    0.000    3.904    2.585
##    .Q12Phys_j           3.754    0.133   28.153    0.000    3.754    2.637
##    .Q12Phys_k           3.684    0.144   25.625    0.000    3.684    2.400
##    .Q12Phys_l           3.991    0.143   27.846    0.000    3.991    2.608
##    .Q12Math_f           5.035    0.123   40.807    0.000    5.035    3.822
```

```
##    .Q12Math_g         4.921    0.124   39.839    0.000    4.921    3.731
##    .Q12Math_h         4.754    0.144   33.039    0.000    4.754    3.094
##    .Q12Math_d         4.719    0.137   34.511    0.000    4.719    3.232
##    .Q12Math_e         4.789    0.133   35.928    0.000    4.789    3.365
##    .Q12Math_a         4.746    0.125   37.913    0.000    4.746    3.551
##    .Q12Math_m         4.675    0.144   32.498    0.000    4.675    3.044
##    .Q12Math_i         4.675    0.126   37.227    0.000    4.675    3.487
##    .Q12Math_j         4.632    0.119   39.081    0.000    4.632    3.660
##    .Q12Math_k         4.535    0.122   37.276    0.000    4.535    3.491
##    .Q12Math_l         4.789    0.115   41.760    0.000    4.789    3.911
##    .Q8f               4.439    0.120   37.095    0.000    4.439    3.474
##    .Q8e               4.649    0.114   40.895    0.000    4.649    3.830
##    .Q8g               4.404    0.117   37.686    0.000    4.404    3.530
##    .Q8j               4.246    0.124   34.299    0.000    4.246    3.212
##    .Q8b               4.430    0.117   37.858    0.000    4.430    3.546
##    .Q8o               4.702    0.106   44.381    0.000    4.702    4.157
##    .Q8n               4.825    0.094   51.402    0.000    4.825    4.814
##    .Q8m               4.649    0.104   44.799    0.000    4.649    4.196
##    .Q8l               4.737    0.107   44.372    0.000    4.737    4.156
##    .Q5c               5.333    0.081   65.818    0.000    5.333    6.164
##    .Q5d               5.351    0.086   62.269    0.000    5.351    5.832
##    .Q5e               5.246    0.091   57.778    0.000    5.246    5.411
##    .Q5g               5.307    0.085   62.317    0.000    5.307    5.836
##    .Q5f               5.246    0.094   55.734    0.000    5.246    5.220
##     erec              0.000                               0.000    0.000
##     eint              0.000                               0.000    0.000
##     epc               0.000                               0.000    0.000
##     prec              0.000                               0.000    0.000
##     pint              0.000                               0.000    0.000
##     ppc               0.000                               0.000    0.000
##     mint              0.000                               0.000    0.000
##     mrec              0.000                               0.000    0.000
##     mpc               0.000                               0.000    0.000
##     intent            0.000                               0.000    0.000
##     fore              0.000                               0.000    0.000
##    .engID             0.000                               0.000    0.000
##    .physID            0.000                               0.000    0.000
##    .mathID            0.000                               0.000    0.000
##    .engagency         0.000                               0.000    0.000
##     agency            0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f           0.433    0.147    2.944    0.003    0.433    0.176
##    .Q3Eng_e           0.836    0.216    3.868    0.000    0.836    0.363
##    .Q3Eng_c           1.383    0.240    5.764    0.000    1.383    0.571
##    .Q3Eng_d           1.297    0.202    6.415    0.000    1.297    0.495
##    .Q3Eng_h           0.283    0.064    4.404    0.000    0.283    0.323
##    .Q3Eng_j           0.390    0.104    3.746    0.000    0.390    0.257
##    .Q3Eng_i           0.171    0.077    2.230    0.026    0.171    0.127
```

```
##    .Q3Eng_k          0.326    0.080    4.100    0.000    0.326    0.214
##    .Q3Eng_l          0.655    0.200    3.267    0.001    0.655    0.367
##    .Q3Eng_m          0.777    0.136    5.726    0.000    0.777    0.478
##    .Q3Eng_n          0.439    0.092    4.773    0.000    0.439    0.320
##    .Q12Phys_c        1.220    0.225    5.430    0.000    1.220    0.475
##    .Q12Phys_d        0.573    0.167    3.438    0.001    0.573    0.189
##    .Q12Phys_a        0.806    0.157    5.125    0.000    0.806    0.321
##    .Q12Phys_m        1.567    0.253    6.185    0.000    1.567    0.443
##    .Q12Phys_f        1.049    0.220    4.763    0.000    1.049    0.486
##    .Q12Phys_g        0.388    0.109    3.579    0.000    0.388    0.140
##    .Q12Phys_h        1.193    0.291    4.105    0.000    1.193    0.392
##    .Q12Phys_i        0.445    0.087    5.125    0.000    0.445    0.195
##    .Q12Phys_j        0.579    0.126    4.597    0.000    0.579    0.286
##    .Q12Phys_k        0.740    0.147    5.044    0.000    0.740    0.314
##    .Q12Phys_l        0.459    0.107    4.284    0.000    0.459    0.196
##    .Q12Math_f        0.702    0.166    4.225    0.000    0.702    0.404
##    .Q12Math_g        0.247    0.082    3.002    0.003    0.247    0.142
##    .Q12Math_h        0.716    0.182    3.943    0.000    0.716    0.303
##    .Q12Math_d        0.816    0.194    4.213    0.000    0.816    0.383
##    .Q12Math_e        0.741    0.207    3.579    0.000    0.741    0.366
##    .Q12Math_a        0.519    0.112    4.652    0.000    0.519    0.291
##    .Q12Math_m        0.930    0.240    3.877    0.000    0.930    0.394
##    .Q12Math_i        0.417    0.110    3.783    0.000    0.417    0.232
##    .Q12Math_j        0.391    0.091    4.282    0.000    0.391    0.244
##    .Q12Math_k        0.450    0.098    4.587    0.000    0.450    0.266
##    .Q12Math_l        0.193    0.053    3.607    0.000    0.193    0.129
##    .Q8f              0.390    0.071    5.460    0.000    0.390    0.239
##    .Q8e              0.443    0.086    5.159    0.000    0.443    0.300
##    .Q8g              0.524    0.095    5.490    0.000    0.524    0.336
##    .Q8j              0.466    0.082    5.662    0.000    0.466    0.267
##    .Q8b              0.574    0.111    5.174    0.000    0.574    0.368
##    .Q8o              0.477    0.108    4.431    0.000    0.477    0.373
##    .Q8n              0.347    0.110    3.143    0.002    0.347    0.346
##    .Q8m              0.410    0.085    4.844    0.000    0.410    0.334
##    .Q8l              0.316    0.086    3.678    0.000    0.316    0.243
##    .Q5c              0.237    0.056    4.251    0.000    0.237    0.317
##    .Q5d              0.142    0.031    4.623    0.000    0.142    0.169
##    .Q5e              0.201    0.051    3.959    0.000    0.201    0.214
##    .Q5g              0.127    0.035    3.665    0.000    0.127    0.153
##    .Q5f              0.215    0.065    3.286    0.001    0.215    0.213
##     erec             1.000                               0.484    0.484
##     eint             1.000                               0.381    0.381
##     epc              1.000                               0.269    0.269
##     prec             1.000                               0.182    0.182
##     pint             1.000                               0.221    0.221
##     ppc              1.000                               0.166    0.166
##     mint             1.000                               0.312    0.312
##     mrec             1.000                               0.170    0.170
##     mpc              1.000                               0.122    0.122
##     intent           1.000                               0.285    0.285
```

```
##     fore              1.000                              0.277    0.277
##    .engID             1.000                              0.373    0.373
##    .physID            1.000                              0.792    0.792
##    .mathID            1.000                              0.814    0.814
##    .engagency         1.000                              0.619    0.619
##     agency            1.000                              1.000    1.000
##
## R-Square:
##                    Estimate
##     Q3Eng_f           0.824
##     Q3Eng_e           0.637
##     Q3Eng_c           0.429
##     Q3Eng_d           0.505
##     Q3Eng_h           0.677
##     Q3Eng_j           0.743
##     Q3Eng_i           0.873
##     Q3Eng_k           0.786
##     Q3Eng_l           0.633
##     Q3Eng_m           0.522
##     Q3Eng_n           0.680
##     Q12Phys_c         0.525
##     Q12Phys_d         0.811
##     Q12Phys_a         0.679
##     Q12Phys_m         0.557
##     Q12Phys_f         0.514
##     Q12Phys_g         0.860
##     Q12Phys_h         0.608
##     Q12Phys_i         0.805
##     Q12Phys_j         0.714
##     Q12Phys_k         0.686
##     Q12Phys_l         0.804
##     Q12Math_f         0.596
##     Q12Math_g         0.858
##     Q12Math_h         0.697
##     Q12Math_d         0.617
##     Q12Math_e         0.634
##     Q12Math_a         0.709
##     Q12Math_m         0.606
##     Q12Math_i         0.768
##     Q12Math_j         0.756
##     Q12Math_k         0.734
##     Q12Math_l         0.871
##     Q8f               0.761
##     Q8e               0.700
##     Q8g               0.664
##     Q8j               0.733
##     Q8b               0.632
##     Q8o               0.627
##     Q8n               0.654
##     Q8m               0.666
```

```
##     Q8l                 0.757
##     Q5c                 0.683
##     Q5d                 0.831
##     Q5e                 0.786
##     Q5g                 0.847
##     Q5f                 0.787
##     erec                0.516
##     eint                0.619
##     epc                 0.731
##     prec                0.818
##     pint                0.779
##     ppc                 0.834
##     mint                0.688
##     mrec                0.830
##     mpc                 0.878
##     intent              0.715
##     fore                0.723
##     engID               0.627
##     physID              0.208
##     mathID              0.186
##     engagency           0.381
##
## Defined Parameters:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     ind1              0.065    0.020    3.202    0.001    0.025    0.025
##     ind3              0.109    0.046    2.360    0.018    0.066    0.066
##     ind4              0.099    0.037    2.697    0.007    0.061    0.061
##     total             0.785    0.120    6.545    0.000    0.569    0.569
```

```
#Model 2: weak invariance (equal loadings):
fit2 <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
            missing = "listwise", estimator = "MLM",group = "Q31b",
group.equal=c("loadings"))

#[Model 1 versus model 2]
anova(fit1, fit2, method = "satorra.bentler.2010") # not sig
```

```
## Scaled Chi Square Difference Test (method = "satorra.bentler.2001")
##
##        Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit1 2027 59376 60707 4115.3
## fit2 2095 59338 60390 4214.0     65.401      68     0.5668
```

```r
#Model 3: strong invariance (equal loadings + intercepts):
fit3 <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
            missing = "listwise", estimator = "MLM", group = "Q31b",
            group.equal=c("loadings", "intercepts"))


summary(fit3, fit.measures = T, standardized = T, modindices = F, rsq = T)

## lavaan 0.6-3 ended normally after 241 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                        340
##   Number of equality constraints                   116
##
##                                                   Used       Total
##   Number of observations per group
##   1                                                342         455
##   0                                                114         140
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                    4262.318    3189.815
##   Degrees of freedom                              2126        2126
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.336
##     for the Satorra-Bentler correction
##
## Chi-square for each group:
##
##   1                                           2365.031    1769.932
##   0                                           1897.287    1419.883
##
## Model test baseline model:
##
##   Minimum Function Test Statistic            20216.072   14956.847
##   Degrees of freedom                              2162        2162
##   P-value                                        0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                    0.882       0.917
##   Tucker-Lewis Index (TLI)                       0.880       0.915
##
##   Robust Comparative Fit Index (CFI)                         0.918
##   Robust Tucker-Lewis Index (TLI)                            0.916
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)             -29438.296  -29438.296
##   Loglikelihood unrestricted model (H1)     -27307.137  -27307.137
```

```
##
##   Number of free parameters                        224         224
##   Akaike (AIC)                               59324.591   59324.591
##   Bayesian (BIC)                             60248.030   60248.030
##   Sample-size adjusted Bayesian (BIC)        59537.126   59537.126
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.066       0.047
##   90 Percent Confidence Interval          0.063  0.069       0.044  0.050
##   P-value RMSEA <= 0.05                          0.000       0.965
##
##   Robust RMSEA                                               0.054
##   90 Percent Confidence Interval                             0.050  0.058
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.072       0.072
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard Errors                           Robust.sem
##
##
## Group 1 [1]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f (.p1.)    1.009    0.066   15.287    0.000    1.331    0.808
##     Q3Eng_e (.p2.)    0.875    0.065   13.367    0.000    1.154    0.721
##     Q3Eng_c (.p3.)    0.898    0.066   13.676    0.000    1.185    0.706
##     Q3Eng_d (.p4.)    0.845    0.072   11.771    0.000    1.114    0.682
##   eint =~
##     Q3Eng_h (.p5.)    0.461    0.048    9.565    0.000    0.940    0.826
##     Q3Eng_j (.p6.)    0.561    0.050   11.204    0.000    1.143    0.887
##     Q3Eng_i (.p7.)    0.543    0.050   10.753    0.000    1.107    0.918
##   epc =~
##     Q3Eng_k (.p8.)    0.560    0.062    8.983    0.000    1.130    0.872
##     Q3Eng_l (.p9.)    0.548    0.061    8.952    0.000    1.104    0.824
##     Q3Eng_m (.10.)    0.570    0.062    9.234    0.000    1.149    0.810
##     Q3Eng_n (.11.)    0.513    0.058    8.873    0.000    1.035    0.809
##   prec =~
##     Q12Phy_ (.12.)    0.496    0.048   10.386    0.000    1.093    0.758
##     Q12Phy_ (.13.)    0.633    0.056   11.254    0.000    1.395    0.820
##     Q12Phy_ (.14.)    0.595    0.054   10.922    0.000    1.312    0.796
##     Q12Phy_ (.15.)    0.650    0.058   11.222    0.000    1.433    0.783
##   pint =~
```

```
##     Q12Phy_ (.16.)    0.573    0.055   10.350    0.000    1.241    0.840
##     Q12Phy_ (.17.)    0.723    0.065   11.122    0.000    1.566    0.941
##     Q12Phy_ (.18.)    0.701    0.065   10.820    0.000    1.518    0.879
##   ppc =~
##     Q12Phy_ (.19.)    0.392    0.076    5.151    0.000    1.426    0.910
##     Q12Phy_ (.20.)    0.377    0.074    5.119    0.000    1.374    0.880
##     Q12Phy_ (.21.)    0.392    0.075    5.219    0.000    1.427    0.889
##     Q12Phy_ (.22.)    0.383    0.073    5.233    0.000    1.395    0.899
##   mint =~
##     Q12Mth_ (.23.)    0.657    0.065   10.076    0.000    1.198    0.807
##     Q12Mth_ (.24.)    0.732    0.068   10.791    0.000    1.334    0.902
##     Q12Mth_ (.25.)    0.681    0.063   10.891    0.000    1.241    0.811
##   mrec =~
##     Q12Mth_ (.26.)    0.376    0.071    5.310    0.000    1.143    0.742
##     Q12Mth_ (.27.)    0.363    0.068    5.315    0.000    1.103    0.730
##     Q12Mth_ (.28.)    0.369    0.069    5.349    0.000    1.121    0.812
##     Q12Mth_ (.29.)    0.414    0.078    5.337    0.000    1.259    0.740
##   mpc =~
##     Q12Mth_ (.30.)    0.328    0.078    4.196    0.000    1.206    0.884
##     Q12Mth_ (.31.)    0.327    0.078    4.193    0.000    1.202    0.861
##     Q12Mth_ (.32.)    0.328    0.078    4.218    0.000    1.206    0.825
##     Q12Mth_ (.33.)    0.322    0.074    4.339    0.000    1.182    0.876
##   intent =~
##     Q8f     (.34.)    0.664    0.072    9.183    0.000    1.140    0.806
##     Q8e     (.35.)    0.607    0.066    9.199    0.000    1.043    0.813
##     Q8g     (.36.)    0.619    0.068    9.053    0.000    1.062    0.784
##     Q8j     (.37.)    0.657    0.070    9.347    0.000    1.127    0.799
##     Q8b     (.38.)    0.571    0.066    8.590    0.000    0.980    0.771
##   fore =~
##     Q8o     (.39.)    0.477    0.055    8.678    0.000    0.953    0.824
##     Q8n     (.40.)    0.489    0.055    8.962    0.000    0.978    0.838
##     Q8m     (.41.)    0.478    0.055    8.622    0.000    0.956    0.706
##     Q8l     (.42.)    0.479    0.053    9.024    0.000    0.959    0.804
##   engID =~
##     eint    (.43.)    1.123    0.141    7.957    0.000    0.872    0.872
##     epc     (.44.)    1.105    0.178    6.227    0.000    0.868    0.868
##     erec    (.45.)    0.543    0.068    7.968    0.000    0.652    0.652
##   physID =~
##     prec    (.46.)    1.725    0.188    9.181    0.000    0.891    0.891
##     pint    (.47.)    1.688    0.195    8.669    0.000    0.887    0.887
##     ppc     (.48.)    3.073    0.641    4.795    0.000    0.962    0.962
##   mathID =~
##     mint    (.49.)    1.396    0.172    8.119    0.000    0.836    0.836
##     mrec    (.50.)    2.630    0.545    4.825    0.000    0.944    0.944
##     mpc     (.51.)    3.242    0.822    3.946    0.000    0.962    0.962
##   engagency =~
##     Q5c     (.52.)    0.689    0.052   13.133    0.000    0.907    0.844
##     Q5d     (.53.)    0.595    0.039   15.207    0.000    0.784    0.765
##     Q5e     (.54.)    0.663    0.053   12.575    0.000    0.872    0.866
##     Q5g     (.55.)    0.690    0.052   13.172    0.000    0.909    0.844
```

```
##     Q5f     (.56.)    0.705    0.055   12.847    0.000    0.928    0.765
##   agency =~
##     fore    (.57.)    1.731    0.248    6.969    0.000    0.866    0.866
##     intent  (.58.)    1.395    0.194    7.190    0.000    0.813    0.813
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)    0.386    0.103    3.744    0.000    0.320    0.320
##     agency     (a)    0.389    0.067    5.801    0.000    0.246    0.246
##   physID ~
##     agency     (b)    0.211    0.068    3.117    0.002    0.185    0.185
##   mathID ~
##     agency     (c)    0.436    0.074    5.926    0.000    0.400    0.400
##   engagency ~
##     agency     (f)    0.677    0.109    6.187    0.000    0.515    0.515
##     mathID     (e)    0.133    0.066    2.021    0.043    0.110    0.110
##     physID     (d)    0.191    0.080    2.401    0.016    0.166    0.166
##   engID ~
##     physID     (g)    0.377    0.078    4.808    0.000    0.271    0.271
##     mathID     (h)    0.261    0.087    2.988    0.003    0.180    0.180
##   physID ~
##     mathID     (a)    0.389    0.067    5.801    0.000    0.373    0.373
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.132)    3.735    0.084   44.389    0.000    3.735    2.269
##    .Q3Eng_e (.133)    3.495    0.080   43.548    0.000    3.495    2.183
##    .Q3Eng_c (.134)    4.303    0.087   49.224    0.000    4.303    2.564
##    .Q3Eng_d (.135)    4.336    0.082   52.663    0.000    4.336    2.654
##    .Q3Eng_h (.136)    5.261    0.062   85.272    0.000    5.261    4.623
##    .Q3Eng_j (.137)    4.856    0.070   69.545    0.000    4.856    3.766
##    .Q3Eng_i (.138)    5.081    0.065   77.596    0.000    5.081    4.214
##    .Q3Eng_k (.139)    4.656    0.069   67.259    0.000    4.656    3.592
##    .Q3Eng_l (.140)    4.511    0.071   63.447    0.000    4.511    3.365
##    .Q3Eng_m (.141)    4.177    0.077   54.364    0.000    4.177    2.946
##    .Q3Eng_n (.142)    4.443    0.067   65.992    0.000    4.443    3.471
##    .Q12Phy_ (.143)    3.373    0.075   45.200    0.000    3.373    2.341
##    .Q12Phy_ (.144)    3.642    0.086   42.170    0.000    3.642    2.140
##    .Q12Phy_ (.145)    3.605    0.084   42.684    0.000    3.605    2.186
##    .Q12Phy_ (.146)    3.568    0.095   37.524    0.000    3.568    1.949
##    .Q12Phy_ (.147)    4.790    0.080   60.144    0.000    4.790    3.244
##    .Q12Phy_ (.148)    4.407    0.090   48.841    0.000    4.407    2.650
##    .Q12Phy_ (.149)    4.048    0.093   43.308    0.000    4.048    2.345
##    .Q12Phy_ (.150)    4.150    0.084   49.155    0.000    4.150    2.647
##    .Q12Phy_ (.151)    4.042    0.084   47.908    0.000    4.042    2.590
##    .Q12Phy_ (.152)    3.868    0.087   44.345    0.000    3.868    2.409
##    .Q12Phy_ (.153)    4.217    0.083   50.953    0.000    4.217    2.715
##    .Q12Mth_ (.154)    4.631    0.081   57.431    0.000    4.631    3.119
##    .Q12Mth_ (.155)    4.473    0.081   55.451    0.000    4.473    3.025
```

```
##    .Q12Mth_ (.156)    4.361    0.080   54.503    0.000    4.361    2.851
##    .Q12Mth_ (.157)    4.353    0.079   55.165    0.000    4.353    2.823
##    .Q12Mth_ (.158)    4.555    0.077   58.971    0.000    4.555    3.013
##    .Q12Mth_ (.159)    4.504    0.073   62.058    0.000    4.504    3.260
##    .Q12Mth_ (.160)    4.338    0.087   49.763    0.000    4.338    2.549
##    .Q12Mth_ (.161)    4.513    0.073   61.810    0.000    4.513    3.307
##    .Q12Mth_ (.162)    4.444    0.075   59.470    0.000    4.444    3.181
##    .Q12Mth_ (.163)    4.335    0.077   56.380    0.000    4.335    2.966
##    .Q12Mth_ (.164)    4.580    0.071   64.203    0.000    4.580    3.392
##    .Q8f     (.165)    4.192    0.074   56.573    0.000    4.192    2.965
##    .Q8e     (.166)    4.400    0.068   65.138    0.000    4.400    3.430
##    .Q8g     (.167)    4.171    0.071   58.700    0.000    4.171    3.078
##    .Q8j     (.168)    3.957    0.073   54.152    0.000    3.957    2.804
##    .Q8b     (.169)    4.184    0.065   64.145    0.000    4.184    3.291
##    .Q8o     (.170)    4.634    0.062   74.586    0.000    4.634    4.008
##    .Q8n     (.171)    4.615    0.064   72.154    0.000    4.615    3.951
##    .Q8m     (.172)    4.445    0.068   65.568    0.000    4.445    3.283
##    .Q8l     (.173)    4.596    0.062   73.793    0.000    4.596    3.853
##    .Q5c     (.174)    5.010    0.059   84.881    0.000    5.010    4.665
##    .Q5d     (.175)    5.192    0.050  103.468    0.000    5.192    5.070
##    .Q5e     (.176)    5.080    0.054   94.430    0.000    5.080    5.045
##    .Q5g     (.177)    5.089    0.058   88.467    0.000    5.089    4.726
##    .Q5f     (.178)    5.002    0.061   82.368    0.000    5.002    4.124
##     erec              0.000                               0.000    0.000
##     eint              0.000                               0.000    0.000
##     epc               0.000                               0.000    0.000
##     prec              0.000                               0.000    0.000
##     pint              0.000                               0.000    0.000
##     ppc               0.000                               0.000    0.000
##     mint              0.000                               0.000    0.000
##     mrec              0.000                               0.000    0.000
##     mpc               0.000                               0.000    0.000
##     intent            0.000                               0.000    0.000
##     fore              0.000                               0.000    0.000
##    .engID             0.000                               0.000    0.000
##    .physID            0.000                               0.000    0.000
##    .mathID            0.000                               0.000    0.000
##    .enggncy           0.000                               0.000    0.000
##     agency            0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f           0.940    0.137    6.861    0.000    0.940    0.347
##    .Q3Eng_e           1.232    0.136    9.055    0.000    1.232    0.480
##    .Q3Eng_c           1.413    0.171    8.246    0.000    1.413    0.502
##    .Q3Eng_d           1.427    0.181    7.898    0.000    1.427    0.535
##    .Q3Eng_h           0.410    0.076    5.370    0.000    0.410    0.317
##    .Q3Eng_j           0.355    0.064    5.589    0.000    0.355    0.214
##    .Q3Eng_i           0.228    0.068    3.353    0.001    0.228    0.157
##    .Q3Eng_k           0.404    0.057    7.076    0.000    0.404    0.240
```

```
##    .Q3Eng_l           0.578    0.084    6.838    0.000    0.578    0.322
##    .Q3Eng_m           0.690    0.068   10.078    0.000    0.690    0.343
##    .Q3Eng_n           0.567    0.093    6.080    0.000    0.567    0.346
##    .Q12Phys_c         0.882    0.089    9.904    0.000    0.882    0.425
##    .Q12Phys_d         0.949    0.113    8.428    0.000    0.949    0.328
##    .Q12Phys_a         0.997    0.123    8.128    0.000    0.997    0.367
##    .Q12Phys_m         1.296    0.152    8.511    0.000    1.296    0.387
##    .Q12Phys_f         0.640    0.073    8.823    0.000    0.640    0.294
##    .Q12Phys_g         0.315    0.063    5.032    0.000    0.315    0.114
##    .Q12Phys_h         0.676    0.127    5.337    0.000    0.676    0.227
##    .Q12Phys_i         0.425    0.060    7.034    0.000    0.425    0.173
##    .Q12Phys_j         0.548    0.070    7.770    0.000    0.548    0.225
##    .Q12Phys_k         0.543    0.065    8.376    0.000    0.543    0.210
##    .Q12Phys_l         0.465    0.067    6.906    0.000    0.465    0.193
##    .Q12Math_f         0.770    0.099    7.804    0.000    0.770    0.349
##    .Q12Math_g         0.407    0.077    5.275    0.000    0.407    0.186
##    .Q12Math_h         0.801    0.113    7.088    0.000    0.801    0.342
##    .Q12Math_d         1.070    0.139    7.705    0.000    1.070    0.450
##    .Q12Math_e         1.068    0.148    7.209    0.000    1.068    0.467
##    .Q12Math_a         0.652    0.088    7.408    0.000    0.652    0.341
##    .Q12Math_m         1.311    0.209    6.268    0.000    1.311    0.453
##    .Q12Math_i         0.407    0.063    6.509    0.000    0.407    0.219
##    .Q12Math_j         0.506    0.065    7.807    0.000    0.506    0.259
##    .Q12Math_k         0.681    0.105    6.507    0.000    0.681    0.319
##    .Q12Math_l         0.426    0.077    5.553    0.000    0.426    0.233
##    .Q8f               0.700    0.101    6.899    0.000    0.700    0.350
##    .Q8e               0.558    0.075    7.417    0.000    0.558    0.339
##    .Q8g               0.707    0.084    8.429    0.000    0.707    0.385
##    .Q8j               0.720    0.099    7.242    0.000    0.720    0.362
##    .Q8b               0.656    0.117    5.610    0.000    0.656    0.406
##    .Q8o               0.429    0.063    6.831    0.000    0.429    0.321
##    .Q8n               0.407    0.066    6.147    0.000    0.407    0.298
##    .Q8m               0.919    0.136    6.775    0.000    0.919    0.501
##    .Q8l               0.504    0.071    7.135    0.000    0.504    0.354
##    .Q5c               0.331    0.047    7.030    0.000    0.331    0.287
##    .Q5d               0.435    0.090    4.842    0.000    0.435    0.415
##    .Q5e               0.253    0.038    6.585    0.000    0.253    0.249
##    .Q5g               0.334    0.063    5.276    0.000    0.334    0.288
##    .Q5f               0.609    0.137    4.456    0.000    0.609    0.414
##     erec              1.000                               0.575    0.575
##     eint              1.000                               0.240    0.240
##     epc               1.000                               0.246    0.246
##     prec              1.000                               0.206    0.206
##     pint              1.000                               0.213    0.213
##     ppc               1.000                               0.075    0.075
##     mint              1.000                               0.301    0.301
##     mrec              1.000                               0.108    0.108
##     mpc               1.000                               0.074    0.074
##     intent            1.000                               0.339    0.339
##     fore              1.000                               0.250    0.250
```

```
##    .engID             1.000                                  0.399    0.399
##    .physID            1.000                                  0.771    0.771
##    .mathID            1.000                                  0.840    0.840
##    .engagency         1.000                                  0.577    0.577
##     agency            1.000                                  1.000    1.000
##
## R-Square:
##                    Estimate
##     Q3Eng_f           0.653
##     Q3Eng_e           0.520
##     Q3Eng_c           0.498
##     Q3Eng_d           0.465
##     Q3Eng_h           0.683
##     Q3Eng_j           0.786
##     Q3Eng_i           0.843
##     Q3Eng_k           0.760
##     Q3Eng_l           0.678
##     Q3Eng_m           0.657
##     Q3Eng_n           0.654
##     Q12Phys_c         0.575
##     Q12Phys_d         0.672
##     Q12Phys_a         0.633
##     Q12Phys_m         0.613
##     Q12Phys_f         0.706
##     Q12Phys_g         0.886
##     Q12Phys_h         0.773
##     Q12Phys_i         0.827
##     Q12Phys_j         0.775
##     Q12Phys_k         0.790
##     Q12Phys_l         0.807
##     Q12Math_f         0.651
##     Q12Math_g         0.814
##     Q12Math_h         0.658
##     Q12Math_d         0.550
##     Q12Math_e         0.533
##     Q12Math_a         0.659
##     Q12Math_m         0.547
##     Q12Math_i         0.781
##     Q12Math_j         0.741
##     Q12Math_k         0.681
##     Q12Math_l         0.767
##     Q8f               0.650
##     Q8e               0.661
##     Q8g               0.615
##     Q8j               0.638
##     Q8b               0.594
##     Q8o               0.679
##     Q8n               0.702
##     Q8m               0.499
##     Q8l               0.646
```

```
##     Q5c                0.713
##     Q5d                0.585
##     Q5e                0.751
##     Q5g                0.712
##     Q5f                0.586
##     erec               0.425
##     eint               0.760
##     epc                0.754
##     prec               0.794
##     pint               0.787
##     ppc                0.925
##     mint               0.699
##     mrec               0.892
##     mpc                0.926
##     intent             0.661
##     fore               0.750
##     engID              0.601
##     physID             0.229
##     mathID             0.160
##     engagency          0.423
##
##
## Group 2 [0]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f (.p1.)    1.009    0.066   15.287    0.000    1.331    0.885
##     Q3Eng_e (.p2.)    0.875    0.065   13.367    0.000    1.154    0.784
##     Q3Eng_c (.p3.)    0.898    0.066   13.676    0.000    1.185    0.712
##     Q3Eng_d (.p4.)    0.845    0.072   11.771    0.000    1.114    0.699
##   eint =~
##     Q3Eng_h (.p5.)    0.461    0.048    9.565    0.000    0.940    0.872
##     Q3Eng_j (.p6.)    0.561    0.050   11.204    0.000    1.143    0.879
##     Q3Eng_i (.p7.)    0.543    0.050   10.753    0.000    1.107    0.923
##   epc =~
##     Q3Eng_k (.p8.)    0.560    0.062    8.983    0.000    1.130    0.879
##     Q3Eng_l (.p9.)    0.548    0.061    8.952    0.000    1.104    0.798
##     Q3Eng_m (.10.)    0.570    0.062    9.234    0.000    1.149    0.796
##     Q3Eng_n (.11.)    0.513    0.058    8.873    0.000    1.035    0.847
##   prec =~
##     Q12Phy_ (.12.)    0.496    0.048   10.386    0.000    1.093    0.702
##     Q12Phy_ (.13.)    0.633    0.056   11.254    0.000    1.395    0.854
##     Q12Phy_ (.14.)    0.595    0.054   10.922    0.000    1.312    0.820
##     Q12Phy_ (.15.)    0.650    0.058   11.222    0.000    1.433    0.758
##   pint =~
##     Q12Phy_ (.16.)    0.573    0.055   10.350    0.000    1.241    0.767
##     Q12Phy_ (.17.)    0.723    0.065   11.122    0.000    1.566    0.919
##     Q12Phy_ (.18.)    0.701    0.065   10.820    0.000    1.518    0.810
##   ppc =~
```

```
##     Q12Phy_ (.19.)    0.392    0.076    5.151    0.000    1.426    0.905
##     Q12Phy_ (.20.)    0.377    0.074    5.119    0.000    1.374    0.874
##     Q12Phy_ (.21.)    0.392    0.075    5.219    0.000    1.427    0.855
##     Q12Phy_ (.22.)    0.383    0.073    5.233    0.000    1.395    0.894
##   mint =~
##     Q12Mth_ (.23.)    0.657    0.065   10.076    0.000    1.198    0.821
##     Q12Mth_ (.24.)    0.732    0.068   10.791    0.000    1.334    0.941
##     Q12Mth_ (.25.)    0.681    0.063   10.891    0.000    1.241    0.815
##   mrec =~
##     Q12Mth_ (.26.)    0.376    0.071    5.310    0.000    1.143    0.777
##     Q12Mth_ (.27.)    0.363    0.068    5.315    0.000    1.103    0.778
##     Q12Mth_ (.28.)    0.369    0.069    5.349    0.000    1.121    0.840
##     Q12Mth_ (.29.)    0.414    0.078    5.337    0.000    1.259    0.790
##   mpc =~
##     Q12Mth_ (.30.)    0.328    0.078    4.196    0.000    1.206    0.878
##     Q12Mth_ (.31.)    0.327    0.078    4.193    0.000    1.202    0.887
##     Q12Mth_ (.32.)    0.328    0.078    4.218    0.000    1.206    0.873
##     Q12Mth_ (.33.)    0.322    0.074    4.339    0.000    1.182    0.938
##   intent =~
##     Q8f     (.34.)    0.664    0.072    9.183    0.000    1.140    0.879
##     Q8e     (.35.)    0.607    0.066    9.199    0.000    1.043    0.844
##     Q8g     (.36.)    0.619    0.068    9.053    0.000    1.062    0.829
##     Q8j     (.37.)    0.657    0.070    9.347    0.000    1.127    0.853
##     Q8b     (.38.)    0.571    0.066    8.590    0.000    0.980    0.788
##   fore =~
##     Q8o     (.39.)    0.477    0.055    8.678    0.000    0.953    0.806
##     Q8n     (.40.)    0.489    0.055    8.962    0.000    0.978    0.862
##     Q8m     (.41.)    0.478    0.055    8.622    0.000    0.956    0.831
##     Q8l     (.42.)    0.479    0.053    9.024    0.000    0.959    0.849
##   engID =~
##     eint    (.43.)    1.123    0.141    7.957    0.000    0.872    0.872
##     epc     (.44.)    1.105    0.178    6.227    0.000    0.868    0.868
##     erec    (.45.)    0.543    0.068    7.968    0.000    0.652    0.652
##   physID =~
##     prec    (.46.)    1.725    0.188    9.181    0.000    0.891    0.891
##     pint    (.47.)    1.688    0.195    8.669    0.000    0.887    0.887
##     ppc     (.48.)    3.073    0.641    4.795    0.000    0.962    0.962
##   mathID =~
##     mint    (.49.)    1.396    0.172    8.119    0.000    0.836    0.836
##     mrec    (.50.)    2.630    0.545    4.825    0.000    0.944    0.944
##     mpc     (.51.)    3.242    0.822    3.946    0.000    0.962    0.962
##   engagency =~
##     Q5c     (.52.)    0.689    0.052   13.133    0.000    0.907    0.870
##     Q5d     (.53.)    0.595    0.039   15.207    0.000    0.784    0.886
##     Q5e     (.54.)    0.663    0.053   12.575    0.000    0.872    0.885
##     Q5g     (.55.)    0.690    0.052   13.172    0.000    0.909    0.933
##     Q5f     (.56.)    0.705    0.055   12.847    0.000    0.928    0.897
##   agency =~
##     fore    (.57.)    1.731    0.248    6.969    0.000    0.866    0.866
##     intent  (.58.)    1.395    0.194    7.190    0.000    0.813    0.813
```

```
##
## Regressions:
##                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)     0.386    0.103    3.744    0.000    0.320    0.320
##     agency     (a)     0.389    0.067    5.801    0.000    0.246    0.246
##   physID ~
##     agency     (b)     0.211    0.068    3.117    0.002    0.185    0.185
##   mathID ~
##     agency     (c)     0.436    0.074    5.926    0.000    0.400    0.400
##   engagency ~
##     agency     (f)     0.677    0.109    6.187    0.000    0.515    0.515
##     mathID     (e)     0.133    0.066    2.021    0.043    0.110    0.110
##     physID     (d)     0.191    0.080    2.401    0.016    0.166    0.166
##   engID ~
##     physID     (g)     0.377    0.078    4.808    0.000    0.271    0.271
##     mathID     (h)     0.261    0.087    2.988    0.003    0.180    0.180
##   physID ~
##     mathID     (a)     0.389    0.067    5.801    0.000    0.373    0.373
##
## Intercepts:
##                      Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.132)     3.735    0.084   44.389    0.000    3.735    2.484
##    .Q3Eng_e (.133)     3.495    0.080   43.548    0.000    3.495    2.374
##    .Q3Eng_c (.134)     4.303    0.087   49.224    0.000    4.303    2.586
##    .Q3Eng_d (.135)     4.336    0.082   52.663    0.000    4.336    2.720
##    .Q3Eng_h (.136)     5.261    0.062   85.272    0.000    5.261    4.876
##    .Q3Eng_j (.137)     4.856    0.070   69.545    0.000    4.856    3.735
##    .Q3Eng_i (.138)     5.081    0.065   77.596    0.000    5.081    4.234
##    .Q3Eng_k (.139)     4.656    0.069   67.259    0.000    4.656    3.621
##    .Q3Eng_l (.140)     4.511    0.071   63.447    0.000    4.511    3.260
##    .Q3Eng_m (.141)     4.177    0.077   54.364    0.000    4.177    2.892
##    .Q3Eng_n (.142)     4.443    0.067   65.992    0.000    4.443    3.638
##    .Q12Phy_ (.143)     3.373    0.075   45.200    0.000    3.373    2.167
##    .Q12Phy_ (.144)     3.642    0.086   42.170    0.000    3.642    2.230
##    .Q12Phy_ (.145)     3.605    0.084   42.684    0.000    3.605    2.252
##    .Q12Phy_ (.146)     3.568    0.095   37.524    0.000    3.568    1.886
##    .Q12Phy_ (.147)     4.790    0.080   60.144    0.000    4.790    2.961
##    .Q12Phy_ (.148)     4.407    0.090   48.841    0.000    4.407    2.586
##    .Q12Phy_ (.149)     4.048    0.093   43.308    0.000    4.048    2.161
##    .Q12Phy_ (.150)     4.150    0.084   49.155    0.000    4.150    2.634
##    .Q12Phy_ (.151)     4.042    0.084   47.908    0.000    4.042    2.572
##    .Q12Phy_ (.152)     3.868    0.087   44.345    0.000    3.868    2.318
##    .Q12Phy_ (.153)     4.217    0.083   50.953    0.000    4.217    2.701
##    .Q12Mth_ (.154)     4.631    0.081   57.431    0.000    4.631    3.176
##    .Q12Mth_ (.155)     4.473    0.081   55.451    0.000    4.473    3.154
##    .Q12Mth_ (.156)     4.361    0.080   54.503    0.000    4.361    2.865
##    .Q12Mth_ (.157)     4.353    0.079   55.165    0.000    4.353    2.958
##    .Q12Mth_ (.158)     4.555    0.077   58.971    0.000    4.555    3.214
##    .Q12Mth_ (.159)     4.504    0.073   62.058    0.000    4.504    3.376
```

```
##    .Q12Mth_ (.160)    4.338    0.087   49.763    0.000    4.338    2.724
##    .Q12Mth_ (.161)    4.513    0.073   61.810    0.000    4.513    3.283
##    .Q12Mth_ (.162)    4.444    0.075   59.470    0.000    4.444    3.276
##    .Q12Mth_ (.163)    4.335    0.077   56.380    0.000    4.335    3.139
##    .Q12Mth_ (.164)    4.580    0.071   64.203    0.000    4.580    3.632
##    .Q8f     (.165)    4.192    0.074   56.573    0.000    4.192    3.235
##    .Q8e     (.166)    4.400    0.068   65.138    0.000    4.400    3.561
##    .Q8g     (.167)    4.171    0.071   58.700    0.000    4.171    3.255
##    .Q8j     (.168)    3.957    0.073   54.152    0.000    3.957    2.993
##    .Q8b     (.169)    4.184    0.065   64.145    0.000    4.184    3.365
##    .Q8o     (.170)    4.634    0.062   74.586    0.000    4.634    3.922
##    .Q8n     (.171)    4.615    0.064   72.154    0.000    4.615    4.064
##    .Q8m     (.172)    4.445    0.068   65.568    0.000    4.445    3.864
##    .Q8l     (.173)    4.596    0.062   73.793    0.000    4.596    4.073
##    .Q5c     (.174)    5.010    0.059   84.881    0.000    5.010    4.807
##    .Q5d     (.175)    5.192    0.050  103.468    0.000    5.192    5.873
##    .Q5e     (.176)    5.080    0.054   94.430    0.000    5.080    5.152
##    .Q5g     (.177)    5.089    0.058   88.467    0.000    5.089    5.223
##    .Q5f     (.178)    5.002    0.061   82.368    0.000    5.002    4.835
##     erec              0.027    0.115    0.233    0.816    0.020    0.020
##     eint              0.069    0.108    0.634    0.526    0.034    0.034
##     epc              -0.314    0.110   -2.864    0.004   -0.156   -0.156
##     prec             -0.017    0.132   -0.130    0.897   -0.008   -0.008
##     pint             -0.058    0.123   -0.471    0.638   -0.027   -0.027
##     ppc              -0.165    0.096   -1.716    0.086   -0.045   -0.045
##     mint              0.289    0.123    2.347    0.019    0.159    0.159
##     mrec              0.160    0.140    1.141    0.254    0.053    0.053
##     mpc              -0.140    0.112   -1.246    0.213   -0.038   -0.038
##     intent            0.205    0.101    2.024    0.043    0.119    0.119
##     fore              0.091    0.089    1.023    0.306    0.045    0.045
##    .engID            -0.177    0.098   -1.797    0.072   -0.112   -0.112
##    .physID           -0.266    0.108   -2.466    0.014   -0.233   -0.233
##    .mathID            0.165    0.105    1.584    0.113    0.152    0.152
##    .enggncy           0.227    0.116    1.959    0.050    0.172    0.172
##     agency            0.142    0.100    1.413    0.158    0.142    0.142
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f           0.490    0.129    3.790    0.000    0.490    0.217
##    .Q3Eng_e           0.835    0.195    4.279    0.000    0.835    0.385
##    .Q3Eng_c           1.365    0.252    5.421    0.000    1.365    0.493
##    .Q3Eng_d           1.301    0.196    6.628    0.000    1.301    0.512
##    .Q3Eng_h           0.280    0.065    4.305    0.000    0.280    0.240
##    .Q3Eng_j           0.383    0.099    3.859    0.000    0.383    0.226
##    .Q3Eng_i           0.214    0.080    2.668    0.008    0.214    0.149
##    .Q3Eng_k           0.377    0.088    4.305    0.000    0.377    0.228
##    .Q3Eng_l           0.696    0.191    3.648    0.000    0.696    0.363
##    .Q3Eng_m           0.766    0.141    5.437    0.000    0.766    0.367
##    .Q3Eng_n           0.421    0.080    5.228    0.000    0.421    0.282
##    .Q12Phys_c         1.230    0.211    5.824    0.000    1.230    0.507
```

```
##    .Q12Phys_d          0.721    0.165    4.361    0.000    0.721    0.270
##    .Q12Phys_a          0.840    0.151    5.566    0.000    0.840    0.328
##    .Q12Phys_m          1.523    0.252    6.036    0.000    1.523    0.426
##    .Q12Phys_f          1.077    0.224    4.812    0.000    1.077    0.412
##    .Q12Phys_g          0.454    0.123    3.699    0.000    0.454    0.156
##    .Q12Phys_h          1.205    0.283    4.253    0.000    1.205    0.343
##    .Q12Phys_i          0.448    0.087    5.174    0.000    0.448    0.180
##    .Q12Phys_j          0.582    0.126    4.599    0.000    0.582    0.236
##    .Q12Phys_k          0.748    0.148    5.038    0.000    0.748    0.269
##    .Q12Phys_l          0.490    0.109    4.475    0.000    0.490    0.201
##    .Q12Math_f          0.691    0.167    4.148    0.000    0.691    0.325
##    .Q12Math_g          0.232    0.078    2.953    0.003    0.232    0.115
##    .Q12Math_h          0.777    0.182    4.266    0.000    0.777    0.335
##    .Q12Math_d          0.858    0.195    4.414    0.000    0.858    0.396
##    .Q12Math_e          0.792    0.190    4.158    0.000    0.792    0.394
##    .Q12Math_a          0.523    0.104    5.053    0.000    0.523    0.294
##    .Q12Math_m          0.953    0.249    3.824    0.000    0.953    0.376
##    .Q12Math_i          0.434    0.119    3.654    0.000    0.434    0.230
##    .Q12Math_j          0.394    0.097    4.068    0.000    0.394    0.214
##    .Q12Math_k          0.453    0.098    4.637    0.000    0.453    0.237
##    .Q12Math_l          0.193    0.044    4.375    0.000    0.193    0.121
##    .Q8f                0.380    0.071    5.329    0.000    0.380    0.227
##    .Q8e                0.440    0.084    5.212    0.000    0.440    0.288
##    .Q8g                0.514    0.093    5.524    0.000    0.514    0.313
##    .Q8j                0.476    0.081    5.882    0.000    0.476    0.273
##    .Q8b                0.585    0.111    5.294    0.000    0.585    0.379
##    .Q8o                0.488    0.110    4.418    0.000    0.488    0.350
##    .Q8n                0.332    0.120    2.767    0.006    0.332    0.258
##    .Q8m                0.410    0.084    4.866    0.000    0.410    0.310
##    .Q8l                0.355    0.077    4.623    0.000    0.355    0.278
##    .Q5c                0.264    0.070    3.762    0.000    0.264    0.243
##    .Q5d                0.168    0.033    5.116    0.000    0.168    0.214
##    .Q5e                0.211    0.048    4.399    0.000    0.211    0.217
##    .Q5g                0.124    0.036    3.449    0.001    0.124    0.130
##    .Q5f                0.208    0.062    3.345    0.001    0.208    0.195
##     erec               1.000                               0.575    0.575
##     eint               1.000                               0.240    0.240
##     epc                1.000                               0.246    0.246
##     prec               1.000                               0.206    0.206
##     pint               1.000                               0.213    0.213
##     ppc                1.000                               0.075    0.075
##     mint               1.000                               0.301    0.301
##     mrec               1.000                               0.108    0.108
##     mpc                1.000                               0.074    0.074
##     intent             1.000                               0.339    0.339
##     fore               1.000                               0.250    0.250
##    .engID              1.000                               0.399    0.399
##    .physID             1.000                               0.771    0.771
##    .mathID             1.000                               0.840    0.840
##    .engagency          1.000                               0.577    0.577
```

```
##     agency              1.000                                1.000    1.000
##
## R-Square:
##                     Estimate
##     Q3Eng_f            0.783
##     Q3Eng_e            0.615
##     Q3Eng_c            0.507
##     Q3Eng_d            0.488
##     Q3Eng_h            0.760
##     Q3Eng_j            0.774
##     Q3Eng_i            0.851
##     Q3Eng_k            0.772
##     Q3Eng_l            0.637
##     Q3Eng_m            0.633
##     Q3Eng_n            0.718
##     Q12Phys_c          0.493
##     Q12Phys_d          0.730
##     Q12Phys_a          0.672
##     Q12Phys_m          0.574
##     Q12Phys_f          0.588
##     Q12Phys_g          0.844
##     Q12Phys_h          0.657
##     Q12Phys_i          0.820
##     Q12Phys_j          0.764
##     Q12Phys_k          0.731
##     Q12Phys_l          0.799
##     Q12Math_f          0.675
##     Q12Math_g          0.885
##     Q12Math_h          0.665
##     Q12Math_d          0.604
##     Q12Math_e          0.606
##     Q12Math_a          0.706
##     Q12Math_m          0.624
##     Q12Math_i          0.770
##     Q12Math_j          0.786
##     Q12Math_k          0.763
##     Q12Math_l          0.879
##     Q8f                0.773
##     Q8e                0.712
##     Q8g                0.687
##     Q8j                0.727
##     Q8b                0.621
##     Q8o                0.650
##     Q8n                0.742
##     Q8m                0.690
##     Q8l                0.722
##     Q5c                0.757
##     Q5d                0.786
##     Q5e                0.783
##     Q5g                0.870
```

```
##     Q5f                0.805
##     erec               0.425
##     eint               0.760
##     epc                0.754
##     prec               0.794
##     pint               0.787
##     ppc                0.925
##     mint               0.699
##     mrec               0.892
##     mpc                0.926
##     intent             0.661
##     fore               0.750
##     engID              0.601
##     physID             0.229
##     mathID             0.160
##     engagency          0.423
##
## Defined Parameters:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     ind1              0.064    0.017    3.680    0.000    0.027    0.027
##     ind3              0.114    0.040    2.859    0.004    0.072    0.072
##     ind4              0.079    0.029    2.742    0.006    0.050    0.050
##     total             0.775    0.096    8.102    0.000    0.566    0.566


#[Model 2 versus model 3]
anova(fit2, fit3, method = "satorra.bentler.2010") #sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2001")
##
##        Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit2 2095 59338 60390 4214.0
## fit3 2126 59325 60248 4262.3     105.38      31  4.929e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


#[Model 1 versus model 3]
anova(fit1, fit3, method = "satorra.bentler.2010") #sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2001")
##
##        Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit1 2027 59376 60707 4115.3
## fit3 2126 59325 60248 4262.3     124.55      99    0.04216 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
options(max.print=1000000)
lavTestScore(fit3,univariate = T, epc = T)
```

```
## $test
##
## total score test:
##
##    test      X2  df p.value
## 1 score 138.322 116   0.077
##
## $uni
##
## univariate score tests:
##
##        lhs op    rhs    X2 df p.value
## 1    .p60. ==  .p68. 0.299  1   0.585
## 2     .p1. == .p195. 2.231  1   0.135
## 3     .p2. == .p196. 0.454  1   0.500
## 4     .p3. == .p197. 4.189  1   0.041
## 5     .p4. == .p198. 0.047  1   0.829
## 6     .p5. == .p199. 5.336  1   0.021
## 7     .p6. == .p200. 0.042  1   0.838
## 8     .p7. == .p201. 1.802  1   0.179
## 9     .p8. == .p202. 0.610  1   0.435
## 10    .p9. == .p203. 0.286  1   0.593
## 11   .p10. == .p204. 4.562  1   0.033
## 12   .p11. == .p205. 0.002  1   0.963
## 13   .p12. == .p206. 0.417  1   0.519
## 14   .p13. == .p207. 4.253  1   0.039
## 15   .p14. == .p208. 0.006  1   0.936
## 16   .p15. == .p209. 0.076  1   0.783
## 17   .p16. == .p210. 2.824  1   0.093
## 18   .p17. == .p211. 1.182  1   0.277
## 19   .p18. == .p212. 0.330  1   0.566
## 20   .p19. == .p213. 0.077  1   0.782
## 21   .p20. == .p214. 1.640  1   0.200
## 22   .p21. == .p215. 1.343  1   0.246
## 23   .p22. == .p216. 0.836  1   0.361
## 24   .p23. == .p217. 2.130  1   0.144
## 25   .p24. == .p218. 0.536  1   0.464
## 26   .p25. == .p219. 1.959  1   0.162
## 27   .p26. == .p220. 0.485  1   0.486
## 28   .p27. == .p221. 0.305  1   0.581
## 29   .p28. == .p222. 0.383  1   0.536
## 30   .p29. == .p223. 0.118  1   0.731
## 31   .p30. == .p224. 0.120  1   0.729
## 32   .p31. == .p225. 0.903  1   0.342
## 33   .p32. == .p226. 0.459  1   0.498
```

```
## 34   .p33. == .p227. 0.796  1   0.372
## 35   .p34. == .p228. 0.053  1   0.817
## 36   .p35. == .p229. 0.042  1   0.838
## 37   .p36. == .p230. 0.339  1   0.560
## 38   .p37. == .p231. 0.236  1   0.627
## 39   .p38. == .p232. 0.217  1   0.641
## 40   .p39. == .p233. 0.258  1   0.611
## 41   .p40. == .p234. 5.826  1   0.016
## 42   .p41. == .p235. 0.019  1   0.890
## 43   .p42. == .p236. 2.284  1   0.131
## 44   .p43. == .p237. 1.355  1   0.244
## 45   .p44. == .p238. 0.305  1   0.581
## 46   .p45. == .p239. 2.916  1   0.088
## 47   .p46. == .p240. 3.736  1   0.053
## 48   .p47. == .p241. 0.241  1   0.624
## 49   .p48. == .p242. 1.361  1   0.243
## 50   .p49. == .p243. 0.642  1   0.423
## 51   .p50. == .p244. 0.325  1   0.569
## 52   .p51. == .p245. 0.156  1   0.693
## 53   .p52. == .p246. 8.979  1   0.003
## 54   .p53. == .p247. 8.102  1   0.004
## 55   .p54. == .p248. 0.265  1   0.607
## 56   .p55. == .p249. 1.126  1   0.289
## 57   .p56. == .p250. 0.536  1   0.464
## 58   .p57. == .p251. 0.868  1   0.352
## 59   .p58. == .p252. 0.220  1   0.639
## 60   .p59. == .p253. 0.620  1   0.431
## 61   .p60. == .p254. 0.977  1   0.323
## 62   .p61. == .p255. 0.613  1   0.434
## 63   .p62. == .p256. 0.081  1   0.776
## 64   .p63. == .p257. 0.136  1   0.712
## 65   .p64. == .p258. 1.567  1   0.211
## 66   .p65. == .p259. 2.614  1   0.106
## 67   .p66. == .p260. 1.728  1   0.189
## 68   .p67. == .p261. 0.179  1   0.672
## 69   .p60. == .p262. 0.213  1   0.645
## 70  .p132. == .p326. 0.006  1   0.937
## 71  .p133. == .p327. 0.128  1   0.721
## 72  .p134. == .p328. 0.116  1   0.734
## 73  .p135. == .p329. 0.032  1   0.857
## 74  .p136. == .p330. 2.383  1   0.123
## 75  .p137. == .p331. 0.519  1   0.471
## 76  .p138. == .p332. 0.435  1   0.510
## 77  .p139. == .p333. 3.316  1   0.069
## 78  .p140. == .p334. 2.497  1   0.114
## 79  .p141. == .p335. 3.002  1   0.083
## 80  .p142. == .p336. 3.577  1   0.059
## 81  .p143. == .p337. 0.148  1   0.701
## 82  .p144. == .p338. 4.923  1   0.027
## 83  .p145. == .p339. 7.788  1   0.005
```

```
## 84  .p146. == .p340. 0.018  1   0.894
## 85  .p147. == .p341. 5.680  1   0.017
## 86  .p148. == .p342. 0.080  1   0.778
## 87  .p149. == .p343. 3.226  1   0.072
## 88  .p150. == .p344. 0.012  1   0.914
## 89  .p151. == .p345. 0.970  1   0.325
## 90  .p152. == .p346. 0.809  1   0.368
## 91  .p153. == .p347. 0.052  1   0.819
## 92  .p154. == .p348. 0.009  1   0.923
## 93  .p155. == .p349. 0.032  1   0.858
## 94  .p156. == .p350. 0.102  1   0.750
## 95  .p157. == .p351. 1.616  1   0.204
## 96  .p158. == .p352. 0.444  1   0.505
## 97  .p159. == .p353. 0.707  1   0.400
## 98  .p160. == .p354. 0.124  1   0.724
## 99  .p161. == .p355. 0.501  1   0.479
## 100 .p162. == .p356. 0.033  1   0.856
## 101 .p163. == .p357. 0.007  1   0.933
## 102 .p164. == .p358. 0.492  1   0.483
## 103 .p165. == .p359. 0.281  1   0.596
## 104 .p166. == .p360. 0.011  1   0.915
## 105 .p167. == .p361. 0.108  1   0.742
## 106 .p168. == .p362. 0.278  1   0.598
## 107 .p169. == .p363. 0.078  1   0.779
## 108 .p170. == .p364. 3.320  1   0.068
## 109 .p171. == .p365. 1.444  1   0.229
## 110 .p172. == .p366. 1.155  1   0.283
## 111 .p173. == .p367. 0.264  1   0.607
## 112 .p174. == .p368. 7.556  1   0.006
## 113 .p175. == .p369. 1.841  1   0.175
## 114 .p176. == .p370. 2.356  1   0.125
## 115 .p177. == .p371. 0.079  1   0.779
## 116 .p178. == .p372. 0.272  1   0.602
##
## $epc
##
## expected parameter changes (epc) and expected parameter values (epv):
##
##           lhs op       rhs group free  label plabel    est    epc    epv
## 1        erec =~   Q3Eng_f     1    1   .p1.   .p1.  1.009  0.011  1.020
## 2        erec =~   Q3Eng_e     1    2   .p2.   .p2.  0.875 -0.005  0.870
## 3        erec =~   Q3Eng_c     1    3   .p3.   .p3.  0.898 -0.080  0.818
## 4        erec =~   Q3Eng_d     1    4   .p4.   .p4.  0.845 -0.017  0.828
## 5        eint =~   Q3Eng_h     1    5   .p5.   .p5.  0.461  0.012  0.473
## 6        eint =~   Q3Eng_j     1    6   .p6.   .p6.  0.561  0.042  0.602
## 7        eint =~   Q3Eng_i     1    7   .p7.   .p7.  0.543  0.048  0.591
## 8         epc =~   Q3Eng_k     1    8   .p8.   .p8.  0.560 -0.001  0.560
## 9         epc =~   Q3Eng_l     1    9   .p9.   .p9.  0.548 -0.002  0.546
## 10        epc =~   Q3Eng_m     1   10  .p10.  .p10.  0.570 -0.030  0.539
## 11        epc =~   Q3Eng_n     1   11  .p11.  .p11.  0.513 -0.006  0.507
```

```
## 12       prec =~ Q12Phys_c     1   12  .p12.  .p12.  0.496  0.000  0.495
## 13       prec =~ Q12Phys_d     1   13  .p13.  .p13.  0.633  0.017  0.650
## 14       prec =~ Q12Phys_a     1   14  .p14.  .p14.  0.595 -0.007  0.588
## 15       prec =~ Q12Phys_m     1   15  .p15.  .p15.  0.650 -0.013  0.637
## 16       pint =~ Q12Phys_f     1   16  .p16.  .p16.  0.573 -0.025  0.548
## 17       pint =~ Q12Phys_g     1   17  .p17.  .p17.  0.723 -0.008  0.714
## 18       pint =~ Q12Phys_h     1   18  .p18.  .p18.  0.701 -0.019  0.682
## 19        ppc =~ Q12Phys_i     1   19  .p19.  .p19.  0.392  0.055  0.447
## 20        ppc =~ Q12Phys_j     1   20  .p20.  .p20.  0.377  0.045  0.423
## 21        ppc =~ Q12Phys_k     1   21  .p21.  .p21.  0.392  0.048  0.440
## 22        ppc =~ Q12Phys_l     1   22  .p22.  .p22.  0.383  0.057  0.440
## 23       mint =~ Q12Math_f     1   23  .p23.  .p23.  0.657 -0.030  0.628
## 24       mint =~ Q12Math_g     1   24  .p24.  .p24.  0.732 -0.018  0.714
## 25       mint =~ Q12Math_h     1   25  .p25.  .p25.  0.681  0.010  0.691
## 26       mrec =~ Q12Math_d     1   26  .p26.  .p26.  0.376  0.056  0.433
## 27       mrec =~ Q12Math_e     1   27  .p27.  .p27.  0.363  0.053  0.416
## 28       mrec =~ Q12Math_a     1   28  .p28.  .p28.  0.369  0.053  0.422
## 29       mrec =~ Q12Math_m     1   29  .p29.  .p29.  0.414  0.050  0.464
## 30        mpc =~ Q12Math_i     1   30  .p30.  .p30.  0.328  0.029  0.357
## 31        mpc =~ Q12Math_j     1   31  .p31.  .p31.  0.327  0.022  0.349
## 32        mpc =~ Q12Math_k     1   32  .p32.  .p32.  0.328  0.022  0.350
## 33        mpc =~ Q12Math_l     1   33  .p33.  .p33.  0.322  0.032  0.353
## 34     intent =~       Q8f     1   34  .p34.  .p34.  0.664 -0.028  0.636
## 35     intent =~       Q8e     1   35  .p35.  .p35.  0.607 -0.025  0.583
## 36     intent =~       Q8g     1   36  .p36.  .p36.  0.619 -0.031  0.588
## 37     intent =~       Q8j     1   37  .p37.  .p37.  0.657 -0.016  0.640
## 38     intent =~       Q8b     1   38  .p38.  .p38.  0.571 -0.014  0.557
## 39       fore =~       Q8o     1   39  .p39.  .p39.  0.477 -0.012  0.465
## 40       fore =~       Q8n     1   40  .p40.  .p40.  0.489 -0.030  0.459
## 41       fore =~       Q8m     1   41  .p41.  .p41.  0.478 -0.005  0.473
## 42       fore =~       Q8l     1   42  .p42.  .p42.  0.479  0.009  0.489
## 43      engID =~      eint     1   43  .p43.  .p43.  1.123 -0.112  1.011
## 44      engID =~       epc     1   44  .p44.  .p44.  1.105  0.017  1.123
## 45      engID =~      erec     1   45  .p45.  .p45.  0.543  0.053  0.596
## 46     physID =~      prec     1   46  .p46.  .p46.  1.725  0.029  1.755
## 47     physID =~      pint     1   47  .p47.  .p47.  1.688  0.000  1.688
## 48     physID =~       ppc     1   48  .p48.  .p48.  3.073 -0.526  2.547
## 49     mathID =~      mint     1   49  .p49.  .p49.  1.396 -0.006  1.391
## 50     mathID =~      mrec     1   50  .p50.  .p50.  2.630 -0.395  2.235
## 51     mathID =~       mpc     1   51  .p51.  .p51.  3.242 -0.329  2.914
## 52  engagency =~       Q5c     1   52  .p52.  .p52.  0.689 -0.040  0.649
## 53  engagency =~       Q5d     1   53  .p53.  .p53.  0.595  0.053  0.648
## 54  engagency =~       Q5e     1   54  .p54.  .p54.  0.663  0.006  0.669
## 55  engagency =~       Q5g     1   55  .p55.  .p55.  0.690 -0.017  0.674
## 56  engagency =~       Q5f     1   56  .p56.  .p56.  0.705  0.016  0.722
## 57     agency =~      fore     1   57  .p57.  .p57.  1.731 -0.012  1.720
## 58     agency =~    intent     1   58  .p58.  .p58.  1.395  0.057  1.453
## 59      engID  ~ engagency     1   59      i  .p59.  0.386 -0.011  0.374
## 60      engID  ~    agency     1   60      a  .p60.  0.389 -0.001  0.388
## 61     physID  ~    agency     1   61      b  .p61.  0.211 -0.034  0.178
```

```
## 62     mathID  ~    agency     1   62       c   .p62.  0.436 -0.002  0.434
## 63  engagency  ~    agency     1   63       f   .p63.  0.677  0.008  0.685
## 64  engagency  ~    mathID     1   64       e   .p64.  0.133 -0.026  0.106
## 65  engagency  ~    physID     1   65       d   .p65.  0.191 -0.039  0.152
## 66      engID  ~    physID     1   66       g   .p66.  0.377 -0.044  0.332
## 67      engID  ~    mathID     1   67       h   .p67.  0.261  0.009  0.270
## 68     physID  ~    mathID     1   68       a   .p68.  0.389  0.040  0.430
## 69    Q3Eng_f ~~   Q3Eng_f     1   69           .p69.  0.940 -0.034  0.906
## 70    Q3Eng_e ~~   Q3Eng_e     1   70           .p70.  1.232 -0.005  1.226
## 71    Q3Eng_c ~~   Q3Eng_c     1   71           .p71.  1.413  0.048  1.461
## 72    Q3Eng_d ~~   Q3Eng_d     1   72           .p72.  1.427  0.003  1.430
## 73    Q3Eng_h ~~   Q3Eng_h     1   73           .p73.  0.410  0.009  0.420
## 74    Q3Eng_j ~~   Q3Eng_j     1   74           .p74.  0.355  0.000  0.355
## 75    Q3Eng_i ~~   Q3Eng_i     1   75           .p75.  0.228 -0.011  0.217
## 76    Q3Eng_k ~~   Q3Eng_k     1   76           .p76.  0.404 -0.006  0.397
## 77    Q3Eng_l ~~   Q3Eng_l     1   77           .p77.  0.578 -0.003  0.574
## 78    Q3Eng_m ~~   Q3Eng_m     1   78           .p78.  0.690  0.013  0.703
## 79    Q3Eng_n ~~   Q3Eng_n     1   79           .p79.  0.567  0.000  0.567
## 80  Q12Phys_c ~~ Q12Phys_c     1   80           .p80.  0.882 -0.002  0.880
## 81  Q12Phys_d ~~ Q12Phys_d     1   81           .p81.  0.949 -0.021  0.928
## 82  Q12Phys_a ~~ Q12Phys_a     1   82           .p82.  0.997  0.003  1.001
## 83  Q12Phys_m ~~ Q12Phys_m     1   83           .p83.  1.296  0.008  1.304
## 84  Q12Phys_f ~~ Q12Phys_f     1   84           .p84.  0.640  0.007  0.647
## 85  Q12Phys_g ~~ Q12Phys_g     1   85           .p85.  0.315 -0.010  0.305
## 86  Q12Phys_h ~~ Q12Phys_h     1   86           .p86.  0.676  0.005  0.681
## 87  Q12Phys_i ~~ Q12Phys_i     1   87           .p87.  0.425 -0.004  0.421
## 88  Q12Phys_j ~~ Q12Phys_j     1   88           .p88.  0.548  0.003  0.551
## 89  Q12Phys_k ~~ Q12Phys_k     1   89           .p89.  0.543  0.002  0.545
## 90  Q12Phys_l ~~ Q12Phys_l     1   90           .p90.  0.465 -0.006  0.459
## 91  Q12Math_f ~~ Q12Math_f     1   91           .p91.  0.770  0.010  0.780
## 92  Q12Math_g ~~ Q12Math_g     1   92           .p92.  0.407  0.007  0.415
## 93  Q12Math_h ~~ Q12Math_h     1   93           .p93.  0.801 -0.015  0.785
## 94  Q12Math_d ~~ Q12Math_d     1   94           .p94.  1.070 -0.015  1.055
## 95  Q12Math_e ~~ Q12Math_e     1   95           .p95.  1.068 -0.013  1.055
## 96  Q12Math_a ~~ Q12Math_a     1   96           .p96.  0.652 -0.016  0.636
## 97  Q12Math_m ~~ Q12Math_m     1   97           .p97.  1.311 -0.007  1.305
## 98  Q12Math_i ~~ Q12Math_i     1   98           .p98.  0.407 -0.004  0.403
## 99  Q12Math_j ~~ Q12Math_j     1   99           .p99.  0.506  0.002  0.508
## 100 Q12Math_k ~~ Q12Math_k     1  100          .p100.  0.681  0.002  0.683
## 101 Q12Math_l ~~ Q12Math_l     1  101          .p101.  0.426 -0.007  0.419
## 102       Q8f ~~       Q8f     1  102          .p102.  0.700  0.003  0.703
## 103       Q8e ~~       Q8e     1  103          .p103.  0.558  0.002  0.560
## 104       Q8g ~~       Q8g     1  104          .p104.  0.707  0.005  0.712
## 105       Q8j ~~       Q8j     1  105          .p105.  0.720 -0.003  0.717
## 106       Q8b ~~       Q8b     1  106          .p106.  0.656 -0.002  0.654
## 107       Q8o ~~       Q8o     1  107          .p107.  0.429  0.002  0.431
## 108       Q8n ~~       Q8n     1  108          .p108.  0.407  0.017  0.424
## 109       Q8m ~~       Q8m     1  109          .p109.  0.919 -0.002  0.917
## 110       Q8l ~~       Q8l     1  110          .p110.  0.504 -0.013  0.491
## 111       Q5c ~~       Q5c     1  111          .p111.  0.331  0.012  0.343
```

```
## 112       Q5d ~~       Q5d      1  112        .p112.  0.435 -0.012  0.423
## 113       Q5e ~~       Q5e      1  113        .p113.  0.253 -0.003  0.250
## 114       Q5g ~~       Q5g      1  114        .p114.  0.334  0.004  0.338
## 115       Q5f ~~       Q5f      1  115        .p115.  0.609 -0.005  0.604
## 116      erec ~~      erec      1    0        .p116.     NA     NA     NA
## 117      eint ~~      eint      1    0        .p117.     NA     NA     NA
## 118       epc ~~       epc      1    0        .p118.     NA     NA     NA
## 119      prec ~~      prec      1    0        .p119.     NA     NA     NA
## 120      pint ~~      pint      1    0        .p120.     NA     NA     NA
## 121       ppc ~~       ppc      1    0        .p121.     NA     NA     NA
## 122      mint ~~      mint      1    0        .p122.     NA     NA     NA
## 123      mrec ~~      mrec      1    0        .p123.     NA     NA     NA
## 124       mpc ~~       mpc      1    0        .p124.     NA     NA     NA
## 125    intent ~~    intent      1    0        .p125.     NA     NA     NA
## 126      fore ~~      fore      1    0        .p126.     NA     NA     NA
## 127     engID ~~     engID      1    0        .p127.     NA     NA     NA
## 128    physID ~~    physID      1    0        .p128.     NA     NA     NA
## 129    mathID ~~    mathID      1    0        .p129.     NA     NA     NA
## 130 engagency ~~ engagency      1    0        .p130.     NA     NA     NA
## 131    agency ~~    agency      1    0        .p131.     NA     NA     NA
## 132   Q3Eng_f ~1                1  116 .p132. .p132.  3.735 -0.002  3.733
## 133   Q3Eng_e ~1                1  117 .p133. .p133.  3.495 -0.011  3.484
## 134   Q3Eng_c ~1                1  118 .p134. .p134.  4.303  0.010  4.313
## 135   Q3Eng_d ~1                1  119 .p135. .p135.  4.336  0.006  4.341
## 136   Q3Eng_h ~1                1  120 .p136. .p136.  5.261  0.027  5.287
## 137   Q3Eng_j ~1                1  121 .p137. .p137.  4.856 -0.009  4.847
## 138   Q3Eng_i ~1                1  122 .p138. .p138.  5.081 -0.006  5.075
## 139   Q3Eng_k ~1                1  123 .p139. .p139.  4.656 -0.026  4.630
## 140   Q3Eng_l ~1                1  124 .p140. .p140.  4.511 -0.027  4.484
## 141   Q3Eng_m ~1                1  125 .p141. .p141.  4.177  0.034  4.210
## 142   Q3Eng_n ~1                1  126 .p142. .p142.  4.443  0.037  4.480
## 143 Q12Phys_c ~1                1  127 .p143. .p143.  3.373  0.008  3.381
## 144 Q12Phys_d ~1                1  128 .p144. .p144.  3.642  0.051  3.694
## 145 Q12Phys_a ~1                1  129 .p145. .p145.  3.605 -0.068  3.537
## 146 Q12Phys_m ~1                1  130 .p146. .p146.  3.568  0.003  3.571
## 147 Q12Phys_f ~1                1  131 .p147. .p147.  4.790  0.038  4.828
## 148 Q12Phys_g ~1                1  132 .p148. .p148.  4.407 -0.002  4.405
## 149 Q12Phys_h ~1                1  133 .p149. .p149.  4.048 -0.028  4.020
## 150 Q12Phys_i ~1                1  134 .p150. .p150.  4.150 -0.002  4.149
## 151 Q12Phys_j ~1                1  135 .p151. .p151.  4.042 -0.017  4.025
## 152 Q12Phys_k ~1                1  136 .p152. .p152.  3.868  0.014  3.882
## 153 Q12Phys_l ~1                1  137 .p153. .p153.  4.217  0.004  4.220
## 154 Q12Math_f ~1                1  138 .p154. .p154.  4.631  0.002  4.633
## 155 Q12Math_g ~1                1  139 .p155. .p155.  4.473  0.002  4.475
## 156 Q12Math_h ~1                1  140 .p156. .p156.  4.361 -0.007  4.355
## 157 Q12Math_d ~1                1  141 .p157. .p157.  4.353  0.034  4.386
## 158 Q12Math_e ~1                1  142 .p158. .p158.  4.555 -0.018  4.537
## 159 Q12Math_a ~1                1  143 .p159. .p159.  4.504 -0.016  4.488
## 160 Q12Math_m ~1                1  144 .p160. .p160.  4.338  0.011  4.349
## 161 Q12Math_i ~1                1  145 .p161. .p161.  4.513 -0.010  4.502
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## 162 Q12Math_j ~1                1  146 .p162. .p162.  4.444 -0.003  4.441
## 163 Q12Math_k ~1                1  147 .p163. .p163.  4.335  0.002  4.337
## 164 Q12Math_l ~1                1  148 .p164. .p164.  4.580  0.013  4.593
## 165       Q8f ~1                1  149 .p165. .p165.  4.192 -0.013  4.179
## 166       Q8e ~1                1  150 .p166. .p166.  4.400  0.002  4.402
## 167       Q8g ~1                1  151 .p167. .p167.  4.171 -0.008  4.163
## 168       Q8j ~1                1  152 .p168. .p168.  3.957  0.012  3.969
## 169       Q8b ~1                1  153 .p169. .p169.  4.184  0.006  4.190
## 170       Q8o ~1                1  154 .p170. .p170.  4.634 -0.027  4.607
## 171       Q8n ~1                1  155 .p171. .p171.  4.615  0.018  4.633
## 172       Q8m ~1                1  156 .p172. .p172.  4.445  0.033  4.477
## 173       Q8l ~1                1  157 .p173. .p173.  4.596 -0.010  4.586
## 174       Q5c ~1                1  158 .p174. .p174.  5.010  0.042  5.051
## 175       Q5d ~1                1  159 .p175. .p175.  5.192 -0.030  5.162
## 176       Q5e ~1                1  160 .p176. .p176.  5.080 -0.020  5.060
## 177       Q5g ~1                1  161 .p177. .p177.  5.089 -0.005  5.083
## 178       Q5f ~1                1  162 .p178. .p178.  5.002  0.014  5.016
## 179      erec ~1                1    0        .p179.     NA     NA     NA
## 180      eint ~1                1    0        .p180.     NA     NA     NA
## 181       epc ~1                1    0        .p181.     NA     NA     NA
## 182      prec ~1                1    0        .p182.     NA     NA     NA
## 183      pint ~1                1    0        .p183.     NA     NA     NA
## 184       ppc ~1                1    0        .p184.     NA     NA     NA
## 185      mint ~1                1    0        .p185.     NA     NA     NA
## 186      mrec ~1                1    0        .p186.     NA     NA     NA
## 187       mpc ~1                1    0        .p187.     NA     NA     NA
## 188    intent ~1                1    0        .p188.     NA     NA     NA
## 189      fore ~1                1    0        .p189.     NA     NA     NA
## 190     engID ~1                1    0        .p190.     NA     NA     NA
## 191    physID ~1                1    0        .p191.     NA     NA     NA
## 192    mathID ~1                1    0        .p192.     NA     NA     NA
## 193 engagency ~1                1    0        .p193.     NA     NA     NA
## 194    agency ~1                1    0        .p194.     NA     NA     NA
## 195      erec =~   Q3Eng_f      2  163   .p1. .p195.  1.009  0.007  1.016
## 196      erec =~   Q3Eng_e      2  164   .p2. .p196.  0.875  0.023  0.898
## 197      erec =~   Q3Eng_c      2  165   .p3. .p197.  0.898  0.207  1.105
## 198      erec =~   Q3Eng_d      2  166   .p4. .p198.  0.845  0.041  0.886
## 199      eint =~   Q3Eng_h      2  167   .p5. .p199.  0.461 -0.053  0.408
## 200      eint =~   Q3Eng_j      2  168   .p6. .p200.  0.561 -0.125  0.436
## 201      eint =~   Q3Eng_i      2  169   .p7. .p201.  0.543 -0.141  0.402
## 202       epc =~   Q3Eng_k      2  170   .p8. .p202.  0.560  0.003  0.563
## 203       epc =~   Q3Eng_l      2  171   .p9. .p203.  0.548  0.005  0.552
## 204       epc =~   Q3Eng_m      2  172  .p10. .p204.  0.570  0.081  0.651
## 205       epc =~   Q3Eng_n      2  173  .p11. .p205.  0.513  0.005  0.519
## 206      prec =~ Q12Phys_c      2  174  .p12. .p206.  0.496 -0.005  0.491
## 207      prec =~ Q12Phys_d      2  175  .p13. .p207.  0.633 -0.037  0.595
## 208      prec =~ Q12Phys_a      2  176  .p14. .p208.  0.595  0.039  0.634
## 209      prec =~ Q12Phys_m      2  177  .p15. .p209.  0.650  0.045  0.695
## 210      pint =~ Q12Phys_f      2  178  .p16. .p210.  0.573  0.086  0.659
## 211      pint =~ Q12Phys_g      2  179  .p17. .p211.  0.723  0.011  0.733
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## 212      pint =~ Q12Phys_h     2  180  .p18. .p212.  0.701  0.075  0.775
## 213       ppc =~ Q12Phys_i     2  181  .p19. .p213.  0.392 -0.178  0.214
## 214       ppc =~ Q12Phys_j     2  182  .p20. .p214.  0.377 -0.143  0.234
## 215       ppc =~ Q12Phys_k     2  183  .p21. .p215.  0.392 -0.154  0.238
## 216       ppc =~ Q12Phys_l     2  184  .p22. .p216.  0.383 -0.184  0.199
## 217      mint =~ Q12Math_f     2  185  .p23. .p217.  0.657  0.076  0.733
## 218      mint =~ Q12Math_g     2  186  .p24. .p218.  0.732  0.041  0.773
## 219      mint =~ Q12Math_h     2  187  .p25. .p219.  0.681 -0.034  0.647
## 220      mrec =~ Q12Math_d     2  188  .p26. .p220.  0.376 -0.115  0.261
## 221      mrec =~ Q12Math_e     2  189  .p27. .p221.  0.363 -0.118  0.245
## 222      mrec =~ Q12Math_a     2  190  .p28. .p222.  0.369 -0.119  0.250
## 223      mrec =~ Q12Math_m     2  191  .p29. .p223.  0.414 -0.105  0.309
## 224       mpc =~ Q12Math_i     2  192  .p30. .p224.  0.328 -0.060  0.269
## 225       mpc =~ Q12Math_j     2  193  .p31. .p225.  0.327 -0.041  0.286
## 226       mpc =~ Q12Math_k     2  194  .p32. .p226.  0.328 -0.044  0.284
## 227       mpc =~ Q12Math_l     2  195  .p33. .p227.  0.322 -0.059  0.263
## 228    intent =~       Q8f     2  196  .p34. .p228.  0.664  0.062  0.726
## 229    intent =~       Q8e     2  197  .p35. .p229.  0.607  0.061  0.668
## 230    intent =~       Q8g     2  198  .p36. .p230.  0.619  0.071  0.690
## 231    intent =~       Q8j     2  199  .p37. .p231.  0.657  0.048  0.704
## 232    intent =~       Q8b     2  200  .p38. .p232.  0.571  0.037  0.608
## 233      fore =~       Q8o     2  201  .p39. .p233.  0.477  0.002  0.479
## 234      fore =~       Q8n     2  202  .p40. .p234.  0.489  0.054  0.544
## 235      fore =~       Q8m     2  203  .p41. .p235.  0.478 -0.002  0.476
## 236      fore =~       Q8l     2  204  .p42. .p236.  0.479 -0.040  0.440
## 237     engID =~      eint     2  205  .p43. .p237.  1.123  0.407  1.530
## 238     engID =~       epc     2  206  .p44. .p238.  1.105  0.040  1.146
## 239     engID =~      erec     2  207  .p45. .p239.  0.543 -0.108  0.435
## 240    physID =~      prec     2  208  .p46. .p240.  1.725 -0.148  1.577
## 241    physID =~      pint     2  209  .p47. .p241.  1.688 -0.031  1.657
## 242    physID =~       ppc     2  210  .p48. .p242.  3.073  1.606  4.679
## 243    mathID =~      mint     2  211  .p49. .p243.  1.396  0.064  1.460
## 244    mathID =~      mrec     2  212  .p50. .p244.  2.630  0.933  3.563
## 245    mathID =~       mpc     2  213  .p51. .p245.  3.242  0.768  4.010
## 246 engagency =~       Q5c     2  214  .p52. .p246.  0.689  0.114  0.803
## 247 engagency =~       Q5d     2  215  .p53. .p247.  0.595 -0.060  0.536
## 248 engagency =~       Q5e     2  216  .p54. .p248.  0.663 -0.017  0.646
## 249 engagency =~       Q5g     2  217  .p55. .p249.  0.690  0.023  0.713
## 250 engagency =~       Q5f     2  218  .p56. .p250.  0.705 -0.007  0.698
## 251    agency =~      fore     2  219  .p57. .p251.  1.731  0.129  1.860
## 252    agency =~    intent     2  220  .p58. .p252.  1.395 -0.157  1.239
## 253     engID  ~ engagency     2  221      i .p253.  0.386  0.161  0.547
## 254     engID  ~    agency     2  222      a .p254.  0.389 -0.400 -0.011
## 255    physID  ~    agency     2  223      b .p255.  0.211  0.039  0.250
## 256    mathID  ~    agency     2  224      c .p256.  0.436 -0.026  0.410
## 257 engagency  ~    agency     2  225      f .p257.  0.677 -0.053  0.624
## 258 engagency  ~    mathID     2  226      e .p258.  0.133  0.085  0.218
## 259 engagency  ~    physID     2  227      d .p259.  0.191  0.114  0.305
## 260     engID  ~    physID     2  228      g .p260.  0.377  0.115  0.492
## 261     engID  ~    mathID     2  229      h .p261.  0.261  0.026  0.287
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## 262    physID  ~    mathID      2  230       a  .p262.  0.389  0.022  0.411
## 263   Q3Eng_f ~~   Q3Eng_f      2  231          .p263.  0.490  0.050  0.540
## 264   Q3Eng_e ~~   Q3Eng_e      2  232          .p264.  0.835  0.001  0.836
## 265   Q3Eng_c ~~   Q3Eng_c      2  233          .p265.  1.365 -0.085  1.280
## 266   Q3Eng_d ~~   Q3Eng_d      2  234          .p266.  1.301 -0.007  1.293
## 267   Q3Eng_h ~~   Q3Eng_h      2  235          .p267.  0.280 -0.021  0.259
## 268   Q3Eng_j ~~   Q3Eng_j      2  236          .p268.  0.383  0.002  0.384
## 269   Q3Eng_i ~~   Q3Eng_i      2  237          .p269.  0.214  0.030  0.244
## 270   Q3Eng_k ~~   Q3Eng_k      2  238          .p270.  0.377  0.012  0.389
## 271   Q3Eng_l ~~   Q3Eng_l      2  239          .p271.  0.696  0.006  0.701
## 272   Q3Eng_m ~~   Q3Eng_m      2  240          .p272.  0.766 -0.035  0.730
## 273   Q3Eng_n ~~   Q3Eng_n      2  241          .p273.  0.421  0.006  0.426
## 274 Q12Phys_c ~~ Q12Phys_c      2  242          .p274.  1.230  0.009  1.239
## 275 Q12Phys_d ~~ Q12Phys_d      2  243          .p275.  0.721  0.062  0.783
## 276 Q12Phys_a ~~ Q12Phys_a      2  244          .p276.  0.840 -0.022  0.818
## 277 Q12Phys_m ~~ Q12Phys_m      2  245          .p277.  1.523 -0.024  1.499
## 278 Q12Phys_f ~~ Q12Phys_f      2  246          .p278.  1.077 -0.039  1.037
## 279 Q12Phys_g ~~ Q12Phys_g      2  247          .p279.  0.454  0.060  0.514
## 280 Q12Phys_h ~~ Q12Phys_h      2  248          .p280.  1.205 -0.041  1.164
## 281 Q12Phys_i ~~ Q12Phys_i      2  249          .p281.  0.448  0.013  0.461
## 282 Q12Phys_j ~~ Q12Phys_j      2  250          .p282.  0.582 -0.013  0.569
## 283 Q12Phys_k ~~ Q12Phys_k      2  251          .p283.  0.748 -0.009  0.739
## 284 Q12Phys_l ~~ Q12Phys_l      2  252          .p284.  0.490  0.021  0.510
## 285 Q12Math_f ~~ Q12Math_f      2  253          .p285.  0.691 -0.016  0.676
## 286 Q12Math_g ~~ Q12Math_g      2  254          .p286.  0.232 -0.016  0.216
## 287 Q12Math_h ~~ Q12Math_h      2  255          .p287.  0.777  0.032  0.809
## 288 Q12Math_d ~~ Q12Math_d      2  256          .p288.  0.858  0.022  0.880
## 289 Q12Math_e ~~ Q12Math_e      2  257          .p289.  0.792  0.026  0.818
## 290 Q12Math_a ~~ Q12Math_a      2  258          .p290.  0.523  0.032  0.555
## 291 Q12Math_m ~~ Q12Math_m      2  259          .p291.  0.953  0.009  0.962
## 292 Q12Math_i ~~ Q12Math_i      2  260          .p292.  0.434  0.005  0.439
## 293 Q12Math_j ~~ Q12Math_j      2  261          .p293.  0.394 -0.005  0.389
## 294 Q12Math_k ~~ Q12Math_k      2  262          .p294.  0.453 -0.003  0.450
## 295 Q12Math_l ~~ Q12Math_l      2  263          .p295.  0.193  0.011  0.203
## 296       Q8f ~~       Q8f      2  264          .p296.  0.380 -0.003  0.378
## 297       Q8e ~~       Q8e      2  265          .p297.  0.440 -0.004  0.436
## 298       Q8g ~~       Q8g      2  266          .p298.  0.514 -0.007  0.507
## 299       Q8j ~~       Q8j      2  267          .p299.  0.476  0.003  0.480
## 300       Q8b ~~       Q8b      2  268          .p300.  0.585  0.004  0.589
## 301       Q8o ~~       Q8o      2  269          .p301.  0.488 -0.001  0.487
## 302       Q8n ~~       Q8n      2  270          .p302.  0.332 -0.036  0.296
## 303       Q8m ~~       Q8m      2  271          .p303.  0.410  0.001  0.411
## 304       Q8l ~~       Q8l      2  272          .p304.  0.355  0.024  0.378
## 305       Q5c ~~       Q5c      2  273          .p305.  0.264 -0.015  0.249
## 306       Q5d ~~       Q5d      2  274          .p306.  0.168  0.009  0.177
## 307       Q5e ~~       Q5e      2  275          .p307.  0.211  0.004  0.215
## 308       Q5g ~~       Q5g      2  276          .p308.  0.124 -0.003  0.120
## 309       Q5f ~~       Q5f      2  277          .p309.  0.208  0.003  0.211
## 310      erec ~~      erec      2    0          .p310.     NA     NA     NA
## 311      eint ~~      eint      2    0          .p311.     NA     NA     NA
```

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## 312       epc ~~       epc      2    0        .p312.     NA     NA     NA
## 313      prec ~~      prec      2    0        .p313.     NA     NA     NA
## 314      pint ~~      pint      2    0        .p314.     NA     NA     NA
## 315       ppc ~~       ppc      2    0        .p315.     NA     NA     NA
## 316      mint ~~      mint      2    0        .p316.     NA     NA     NA
## 317      mrec ~~      mrec      2    0        .p317.     NA     NA     NA
## 318       mpc ~~       mpc      2    0        .p318.     NA     NA     NA
## 319    intent ~~    intent      2    0        .p319.     NA     NA     NA
## 320      fore ~~      fore      2    0        .p320.     NA     NA     NA
## 321     engID ~~     engID      2    0        .p321.     NA     NA     NA
## 322    physID ~~    physID      2    0        .p322.     NA     NA     NA
## 323    mathID ~~    mathID      2    0        .p323.     NA     NA     NA
## 324 engagency ~~ engagency      2    0        .p324.     NA     NA     NA
## 325    agency ~~    agency      2    0        .p325.     NA     NA     NA
## 326   Q3Eng_f ~1                2  278 .p132. .p326.  3.735  0.010  3.745
## 327   Q3Eng_e ~1                2  279 .p133. .p327.  3.495  0.027  3.522
## 328   Q3Eng_c ~1                2  280 .p134. .p328.  4.303 -0.030  4.273
## 329   Q3Eng_d ~1                2  281 .p135. .p329.  4.336 -0.011  4.325
## 330   Q3Eng_h ~1                2  282 .p136. .p330.  5.261 -0.053  5.208
## 331   Q3Eng_j ~1                2  283 .p137. .p331.  4.856  0.038  4.894
## 332   Q3Eng_i ~1                2  284 .p138. .p332.  5.081  0.026  5.107
## 333   Q3Eng_k ~1                2  285 .p139. .p333.  4.656  0.074  4.729
## 334   Q3Eng_l ~1                2  286 .p140. .p334.  4.511  0.100  4.611
## 335   Q3Eng_m ~1                2  287 .p141. .p335.  4.177 -0.086  4.091
## 336   Q3Eng_n ~1                2  288 .p142. .p336.  4.443 -0.080  4.364
## 337 Q12Phys_c ~1                2  289 .p143. .p337.  3.373 -0.040  3.333
## 338 Q12Phys_d ~1                2  290 .p144. .p338.  3.642 -0.135  3.508
## 339 Q12Phys_a ~1                2  291 .p145. .p339.  3.605  0.175  3.780
## 340 Q12Phys_m ~1                2  292 .p146. .p340.  3.568 -0.007  3.560
## 341 Q12Phys_f ~1                2  293 .p147. .p341.  4.790 -0.175  4.615
## 342 Q12Phys_g ~1                2  294 .p148. .p342.  4.407  0.003  4.410
## 343 Q12Phys_h ~1                2  295 .p149. .p343.  4.048  0.162  4.210
## 344 Q12Phys_i ~1                2  296 .p150. .p344.  4.150 -0.005  4.146
## 345 Q12Phys_j ~1                2  297 .p151. .p345.  4.042  0.062  4.103
## 346 Q12Phys_k ~1                2  298 .p152. .p346.  3.868 -0.054  3.814
## 347 Q12Phys_l ~1                2  299 .p153. .p347.  4.217 -0.027  4.190
## 348 Q12Math_f ~1                2  300 .p154. .p348.  4.631 -0.044  4.587
## 349 Q12Math_g ~1                2  301 .p155. .p349.  4.473 -0.019  4.454
## 350 Q12Math_h ~1                2  302 .p156. .p350.  4.361  0.049  4.411
## 351 Q12Math_d ~1                2  303 .p157. .p351.  4.353 -0.065  4.287
## 352 Q12Math_e ~1                2  304 .p158. .p352.  4.555  0.062  4.617
## 353 Q12Math_a ~1                2  305 .p159. .p353.  4.504  0.059  4.564
## 354 Q12Math_m ~1                2  306 .p160. .p354.  4.338 -0.022  4.317
## 355 Q12Math_i ~1                2  307 .p161. .p355.  4.513  0.028  4.541
## 356 Q12Math_j ~1                2  308 .p162. .p356.  4.444 -0.009  4.435
## 357 Q12Math_k ~1                2  309 .p163. .p357.  4.335 -0.019  4.316
## 358 Q12Math_l ~1                2  310 .p164. .p358.  4.580 -0.023  4.557
## 359       Q8f ~1                2  311 .p165. .p359.  4.192  0.019  4.211
## 360       Q8e ~1                2  312 .p166. .p360.  4.400 -0.008  4.392
## 361       Q8g ~1                2  313 .p167. .p361.  4.171  0.010  4.180
```

```
## 362       Q8j ~1              2  314 .p168. .p362.  3.957 -0.020  3.936
## 363       Q8b ~1              2  315 .p169. .p363.  4.184 -0.010  4.174
## 364       Q8o ~1              2  316 .p170. .p364.  4.634  0.087  4.721
## 365       Q8n ~1              2  317 .p171. .p365.  4.615 -0.068  4.547
## 366       Q8m ~1              2  318 .p172. .p366.  4.445 -0.047  4.398
## 367       Q8l ~1              2  319 .p173. .p367.  4.596  0.029  4.625
## 368       Q5c ~1              2  320 .p174. .p368.  5.010 -0.129  4.881
## 369       Q5d ~1              2  321 .p175. .p369.  5.192  0.061  5.254
## 370       Q5e ~1              2  322 .p176. .p370.  5.080  0.063  5.143
## 371       Q5g ~1              2  323 .p177. .p371.  5.089  0.007  5.095
## 372       Q5f ~1              2  324 .p178. .p372.  5.002 -0.004  4.999
## 373      erec ~1              2  325        .p373.  0.027 -0.002  0.025
## 374      eint ~1              2  326        .p374.  0.069  0.011  0.080
## 375       epc ~1              2  327        .p375. -0.314  0.007 -0.308
## 376      prec ~1              2  328        .p376. -0.017 -0.005 -0.023
## 377      pint ~1              2  329        .p377. -0.058  0.015 -0.043
## 378       ppc ~1              2  330        .p378. -0.165 -0.010 -0.175
## 379      mint ~1              2  331        .p379.  0.289 -0.009  0.280
## 380      mrec ~1              2  332        .p380.  0.160  0.011  0.171
## 381       mpc ~1              2  333        .p381. -0.140 -0.007 -0.147
## 382    intent ~1              2  334        .p382.  0.205 -0.005  0.199
## 383      fore ~1              2  335        .p383.  0.091  0.000  0.091
## 384     engID ~1              2  336        .p384. -0.177  0.019 -0.158
## 385    physID ~1              2  337        .p385. -0.266 -0.007 -0.273
## 386    mathID ~1              2  338        .p386.  0.165 -0.007  0.159
## 387 engagency ~1              2  339        .p387.  0.227 -0.001  0.225
## 388    agency ~1              2  340        .p388.  0.142 -0.005  0.136
```

```
strong.mi <- modindices(fit3)
strong.mi <- strong.mi[strong.mi$op == "~1",]
strong.mi[order(strong.mi$mi, decreasing = TRUE),]
```

```
##  [1] lhs      op       rhs      block    group    level    mi
##  [8] epc      sepc.lv  sepc.all sepc.nox
## <0 rows> (or 0-length row.names)
```

```
#Model 3: strong invariance (equal loadings + intercepts) with intercepts
freely estimated:
fit3.2 <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
              missing = "listwise", estimator = "MLM",group = "Q31b",
              group.equal=c("loadings", "intercepts") ,
              group.partial = c("Q12Phys_d~1","Q12Phys_a~1","Q12Phys_f~1",
                                "Q3Eng_n~1","Q3Eng_m~1"))
```

```r
summary(fit3.2, fit.measures = T, standardized = T, modindices = F, rsq = T)
```

```
## lavaan 0.6-3 ended normally after 234 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                        340
##   Number of equality constraints                   111
##
##                                                   Used       Total
##   Number of observations per group
##   1                                                342         455
##   0                                                114         140
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                    4238.302    3159.081
##   Degrees of freedom                              2121        2121
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.342
##     for the Satorra-Bentler correction
##
## Chi-square for each group:
##
##   1                                           2359.188    1758.455
##   0                                           1879.114    1400.625
##
## Model test baseline model:
##
##   Minimum Function Test Statistic            20216.072   14956.847
##   Degrees of freedom                              2162        2162
##   P-value                                        0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                    0.883       0.919
##   Tucker-Lewis Index (TLI)                       0.880       0.917
##
##   Robust Comparative Fit Index (CFI)                         0.919
##   Robust Tucker-Lewis Index (TLI)                            0.918
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)             -29426.287  -29426.287
##   Loglikelihood unrestricted model (H1)     -27307.137  -27307.137
##
##   Number of free parameters                        229         229
```

```
##   Akaike (AIC)                               59310.575   59310.575
##   Bayesian (BIC)                             60254.626   60254.626
##   Sample-size adjusted Bayesian (BIC)        59527.854   59527.854
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.066       0.046
##   90 Percent Confidence Interval          0.063  0.069       0.043  0.049
##   P-value RMSEA <= 0.05                          0.000       0.982
##
##   Robust RMSEA                                               0.054
##   90 Percent Confidence Interval                             0.050  0.058
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.071       0.071
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard Errors                           Robust.sem
##
##
## Group 1 [1]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f (.p1.)    1.009    0.066   15.286    0.000    1.331    0.808
##     Q3Eng_e (.p2.)    0.875    0.065   13.367    0.000    1.154    0.721
##     Q3Eng_c (.p3.)    0.898    0.066   13.674    0.000    1.185    0.706
##     Q3Eng_d (.p4.)    0.845    0.072   11.769    0.000    1.114    0.682
##   eint =~
##     Q3Eng_h (.p5.)    0.462    0.048    9.580    0.000    0.940    0.826
##     Q3Eng_j (.p6.)    0.562    0.050   11.226    0.000    1.143    0.887
##     Q3Eng_i (.p7.)    0.544    0.050   10.771    0.000    1.107    0.918
##   epc =~
##     Q3Eng_k (.p8.)    0.558    0.062    9.007    0.000    1.125    0.870
##     Q3Eng_l (.p9.)    0.546    0.061    8.985    0.000    1.101    0.823
##     Q3Eng_m (.10.)    0.572    0.062    9.270    0.000    1.154    0.813
##     Q3Eng_n (.11.)    0.516    0.058    8.893    0.000    1.041    0.811
##   prec =~
##     Q12Phy_ (.12.)    0.499    0.048   10.493    0.000    1.094    0.759
##     Q12Phy_ (.13.)    0.640    0.056   11.409    0.000    1.404    0.823
##     Q12Phy_ (.14.)    0.596    0.054   11.024    0.000    1.306    0.795
##     Q12Phy_ (.15.)    0.653    0.057   11.366    0.000    1.433    0.783
##   pint =~
##     Q12Phy_ (.16.)    0.574    0.056   10.317    0.000    1.246    0.842
##     Q12Phy_ (.17.)    0.720    0.065   11.085    0.000    1.563    0.941
```

```
##     Q12Phy_ (.18.)    0.699    0.065   10.785    0.000    1.518    0.879
##   ppc =~
##     Q12Phy_ (.19.)    0.394    0.076    5.200    0.000    1.426    0.910
##     Q12Phy_ (.20.)    0.379    0.073    5.168    0.000    1.374    0.880
##     Q12Phy_ (.21.)    0.394    0.075    5.269    0.000    1.427    0.889
##     Q12Phy_ (.22.)    0.385    0.073    5.283    0.000    1.395    0.898
##   mint =~
##     Q12Mth_ (.23.)    0.657    0.065   10.076    0.000    1.198    0.807
##     Q12Mth_ (.24.)    0.732    0.068   10.791    0.000    1.334    0.902
##     Q12Mth_ (.25.)    0.681    0.063   10.891    0.000    1.241    0.811
##   mrec =~
##     Q12Mth_ (.26.)    0.376    0.071    5.311    0.000    1.143    0.742
##     Q12Mth_ (.27.)    0.363    0.068    5.316    0.000    1.103    0.730
##     Q12Mth_ (.28.)    0.369    0.069    5.350    0.000    1.121    0.812
##     Q12Mth_ (.29.)    0.414    0.078    5.338    0.000    1.259    0.740
##   mpc =~
##     Q12Mth_ (.30.)    0.328    0.078    4.195    0.000    1.206    0.884
##     Q12Mth_ (.31.)    0.327    0.078    4.192    0.000    1.202    0.861
##     Q12Mth_ (.32.)    0.328    0.078    4.217    0.000    1.206    0.825
##     Q12Mth_ (.33.)    0.322    0.074    4.338    0.000    1.182    0.876
##   intent =~
##     Q8f     (.34.)    0.664    0.072    9.184    0.000    1.140    0.806
##     Q8e     (.35.)    0.607    0.066    9.200    0.000    1.043    0.813
##     Q8g     (.36.)    0.619    0.068    9.054    0.000    1.062    0.784
##     Q8j     (.37.)    0.657    0.070    9.348    0.000    1.127    0.799
##     Q8b     (.38.)    0.571    0.066    8.590    0.000    0.980    0.771
##   fore =~
##     Q8o     (.39.)    0.476    0.055    8.676    0.000    0.953    0.824
##     Q8n     (.40.)    0.489    0.055    8.960    0.000    0.978    0.838
##     Q8m     (.41.)    0.478    0.055    8.620    0.000    0.956    0.706
##     Q8l     (.42.)    0.479    0.053    9.021    0.000    0.959    0.804
##   engID =~
##     eint    (.43.)    1.119    0.140    7.967    0.000    0.871    0.871
##     epc     (.44.)    1.105    0.177    6.239    0.000    0.868    0.868
##     erec    (.45.)    0.543    0.068    7.968    0.000    0.652    0.652
##   physID =~
##     prec    (.46.)    1.714    0.185    9.268    0.000    0.890    0.890
##     pint    (.47.)    1.692    0.196    8.644    0.000    0.888    0.888
##     ppc     (.48.)    3.055    0.632    4.837    0.000    0.961    0.961
##   mathID =~
##     mint    (.49.)    1.396    0.172    8.120    0.000    0.836    0.836
##     mrec    (.50.)    2.630    0.545    4.826    0.000    0.944    0.944
##     mpc     (.51.)    3.243    0.822    3.945    0.000    0.962    0.962
##   engagency =~
##     Q5c     (.52.)    0.689    0.052   13.135    0.000    0.907    0.844
##     Q5d     (.53.)    0.595    0.039   15.208    0.000    0.784    0.765
##     Q5e     (.54.)    0.663    0.053   12.577    0.000    0.872    0.866
##     Q5g     (.55.)    0.690    0.052   13.174    0.000    0.909    0.844
##     Q5f     (.56.)    0.705    0.055   12.850    0.000    0.928    0.765
##   agency =~
```

```
##     fore    (.57.)    1.732    0.249    6.968    0.000    0.866    0.866
##     intent  (.58.)    1.395    0.194    7.191    0.000    0.813    0.813
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)    0.386    0.103    3.744    0.000    0.320    0.320
##     agency     (a)    0.390    0.067    5.803    0.000    0.246    0.246
##   physID ~
##     agency     (b)    0.211    0.068    3.122    0.002    0.186    0.186
##   mathID ~
##     agency     (c)    0.436    0.074    5.925    0.000    0.400    0.400
##   engagency ~
##     agency     (f)    0.677    0.109    6.186    0.000    0.515    0.515
##     mathID     (e)    0.133    0.066    2.020    0.043    0.110    0.110
##     physID     (d)    0.192    0.080    2.401    0.016    0.166    0.166
##   engID ~
##     physID     (g)    0.377    0.078    4.811    0.000    0.271    0.271
##     mathID     (h)    0.262    0.087    2.993    0.003    0.180    0.180
##   physID ~
##     mathID     (a)    0.390    0.067    5.803    0.000    0.373    0.373
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.132)    3.735    0.084   44.388    0.000    3.735    2.269
##    .Q3Eng_e (.133)    3.495    0.080   43.548    0.000    3.495    2.183
##    .Q3Eng_c (.134)    4.303    0.087   49.225    0.000    4.303    2.563
##    .Q3Eng_d (.135)    4.336    0.082   52.664    0.000    4.336    2.654
##    .Q3Eng_h (.136)    5.261    0.062   85.271    0.000    5.261    4.623
##    .Q3Eng_j (.137)    4.856    0.070   69.546    0.000    4.856    3.766
##    .Q3Eng_i (.138)    5.081    0.065   77.595    0.000    5.081    4.214
##    .Q3Eng_k (.139)    4.684    0.070   67.086    0.000    4.684    3.623
##    .Q3Eng_l (.140)    4.534    0.071   63.424    0.000    4.534    3.388
##    .Q3Eng_m           4.143    0.080   52.091    0.000    4.143    2.917
##    .Q3Eng_n           4.406    0.070   62.764    0.000    4.406    3.434
##    .Q12Phy_ (.143)    3.369    0.075   44.913    0.000    3.369    2.338
##    .Q12Phy_           3.591    0.089   40.167    0.000    3.591    2.104
##    .Q12Phy_           3.673    0.089   41.424    0.000    3.673    2.234
##    .Q12Phy_ (.146)    3.561    0.097   36.887    0.000    3.561    1.945
##    .Q12Phy_           4.751    0.082   58.115    0.000    4.751    3.212
##    .Q12Phy_ (.148)    4.418    0.090   48.950    0.000    4.418    2.660
##    .Q12Phy_ (.149)    4.057    0.093   43.402    0.000    4.057    2.351
##    .Q12Phy_ (.150)    4.150    0.084   49.155    0.000    4.150    2.647
##    .Q12Phy_ (.151)    4.042    0.084   47.908    0.000    4.042    2.590
##    .Q12Phy_ (.152)    3.868    0.087   44.345    0.000    3.868    2.409
##    .Q12Phy_ (.153)    4.217    0.083   50.953    0.000    4.217    2.715
##    .Q12Mth_ (.154)    4.631    0.081   57.431    0.000    4.631    3.119
##    .Q12Mth_ (.155)    4.473    0.081   55.451    0.000    4.473    3.025
##    .Q12Mth_ (.156)    4.361    0.080   54.503    0.000    4.361    2.851
##    .Q12Mth_ (.157)    4.353    0.079   55.165    0.000    4.353    2.823
```

```
##    .Q12Mth_ (.158)    4.555    0.077   58.971    0.000    4.555    3.013
##    .Q12Mth_ (.159)    4.504    0.073   62.058    0.000    4.504    3.260
##    .Q12Mth_ (.160)    4.338    0.087   49.763    0.000    4.338    2.549
##    .Q12Mth_ (.161)    4.513    0.073   61.810    0.000    4.513    3.307
##    .Q12Mth_ (.162)    4.444    0.075   59.470    0.000    4.444    3.181
##    .Q12Mth_ (.163)    4.335    0.077   56.380    0.000    4.335    2.966
##    .Q12Mth_ (.164)    4.580    0.071   64.203    0.000    4.580    3.392
##    .Q8f     (.165)    4.192    0.074   56.573    0.000    4.192    2.965
##    .Q8e     (.166)    4.400    0.068   65.138    0.000    4.400    3.430
##    .Q8g     (.167)    4.171    0.071   58.700    0.000    4.171    3.078
##    .Q8j     (.168)    3.957    0.073   54.152    0.000    3.957    2.804
##    .Q8b     (.169)    4.184    0.065   64.145    0.000    4.184    3.291
##    .Q8o     (.170)    4.634    0.062   74.586    0.000    4.634    4.008
##    .Q8n     (.171)    4.615    0.064   72.154    0.000    4.615    3.951
##    .Q8m     (.172)    4.445    0.068   65.568    0.000    4.445    3.283
##    .Q8l     (.173)    4.596    0.062   73.793    0.000    4.596    3.853
##    .Q5c     (.174)    5.010    0.059   84.882    0.000    5.010    4.665
##    .Q5d     (.175)    5.192    0.050  103.468    0.000    5.192    5.070
##    .Q5e     (.176)    5.080    0.054   94.429    0.000    5.080    5.045
##    .Q5g     (.177)    5.089    0.058   88.467    0.000    5.089    4.726
##    .Q5f     (.178)    5.002    0.061   82.367    0.000    5.002    4.124
##     erec              0.000                                0.000    0.000
##     eint              0.000                                0.000    0.000
##     epc               0.000                                0.000    0.000
##     prec              0.000                                0.000    0.000
##     pint              0.000                                0.000    0.000
##     ppc               0.000                                0.000    0.000
##     mint              0.000                                0.000    0.000
##     mrec              0.000                                0.000    0.000
##     mpc               0.000                                0.000    0.000
##     intent            0.000                                0.000    0.000
##     fore              0.000                                0.000    0.000
##    .engID             0.000                                0.000    0.000
##    .physID            0.000                                0.000    0.000
##    .mathID            0.000                                0.000    0.000
##    .enggncy           0.000                                0.000    0.000
##     agency            0.000                                0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f           0.940    0.137    6.859    0.000    0.940    0.347
##    .Q3Eng_e           1.231    0.136    9.053    0.000    1.231    0.480
##    .Q3Eng_c           1.413    0.171    8.247    0.000    1.413    0.502
##    .Q3Eng_d           1.427    0.181    7.899    0.000    1.427    0.535
##    .Q3Eng_h           0.410    0.076    5.370    0.000    0.410    0.317
##    .Q3Eng_j           0.355    0.064    5.589    0.000    0.355    0.214
##    .Q3Eng_i           0.228    0.068    3.349    0.001    0.228    0.157
##    .Q3Eng_k           0.405    0.057    7.111    0.000    0.405    0.242
##    .Q3Eng_l           0.579    0.084    6.878    0.000    0.579    0.323
##    .Q3Eng_m           0.685    0.068   10.027    0.000    0.685    0.340
```

```
##    .Q3Eng_n          0.563    0.093    6.039    0.000    0.563    0.342
##    .Q12Phys_c        0.879    0.089    9.907    0.000    0.879    0.423
##    .Q12Phys_d        0.940    0.112    8.364    0.000    0.940    0.323
##    .Q12Phys_a        0.996    0.123    8.114    0.000    0.996    0.368
##    .Q12Phys_m        1.297    0.152    8.535    0.000    1.297    0.387
##    .Q12Phys_f        0.637    0.073    8.755    0.000    0.637    0.291
##    .Q12Phys_g        0.317    0.062    5.080    0.000    0.317    0.115
##    .Q12Phys_h        0.675    0.127    5.331    0.000    0.675    0.227
##    .Q12Phys_i        0.425    0.060    7.031    0.000    0.425    0.173
##    .Q12Phys_j        0.547    0.070    7.767    0.000    0.547    0.225
##    .Q12Phys_k        0.543    0.065    8.377    0.000    0.543    0.211
##    .Q12Phys_l        0.465    0.067    6.901    0.000    0.465    0.193
##    .Q12Math_f        0.770    0.099    7.804    0.000    0.770    0.349
##    .Q12Math_g        0.407    0.077    5.276    0.000    0.407    0.186
##    .Q12Math_h        0.801    0.113    7.088    0.000    0.801    0.342
##    .Q12Math_d        1.070    0.139    7.705    0.000    1.070    0.450
##    .Q12Math_e        1.068    0.148    7.209    0.000    1.068    0.467
##    .Q12Math_a        0.652    0.088    7.408    0.000    0.652    0.341
##    .Q12Math_m        1.312    0.209    6.268    0.000    1.312    0.453
##    .Q12Math_i        0.407    0.063    6.509    0.000    0.407    0.219
##    .Q12Math_j        0.506    0.065    7.807    0.000    0.506    0.259
##    .Q12Math_k        0.681    0.105    6.507    0.000    0.681    0.319
##    .Q12Math_l        0.426    0.077    5.553    0.000    0.426    0.233
##    .Q8f              0.700    0.101    6.899    0.000    0.700    0.350
##    .Q8e              0.558    0.075    7.417    0.000    0.558    0.339
##    .Q8g              0.707    0.084    8.429    0.000    0.707    0.385
##    .Q8j              0.720    0.099    7.242    0.000    0.720    0.362
##    .Q8b              0.656    0.117    5.610    0.000    0.656    0.406
##    .Q8o              0.429    0.063    6.830    0.000    0.429    0.321
##    .Q8n              0.407    0.066    6.147    0.000    0.407    0.298
##    .Q8m              0.919    0.136    6.775    0.000    0.919    0.501
##    .Q8l              0.504    0.071    7.135    0.000    0.504    0.354
##    .Q5c              0.331    0.047    7.030    0.000    0.331    0.287
##    .Q5d              0.435    0.090    4.842    0.000    0.435    0.415
##    .Q5e              0.253    0.038    6.585    0.000    0.253    0.249
##    .Q5g              0.334    0.063    5.275    0.000    0.334    0.288
##    .Q5f              0.609    0.137    4.456    0.000    0.609    0.414
##     erec             1.000                               0.575    0.575
##     eint             1.000                               0.241    0.241
##     epc              1.000                               0.246    0.246
##     prec             1.000                               0.208    0.208
##     pint             1.000                               0.212    0.212
##     ppc              1.000                               0.076    0.076
##     mint             1.000                               0.301    0.301
##     mrec             1.000                               0.108    0.108
##     mpc              1.000                               0.074    0.074
##     intent           1.000                               0.339    0.339
##     fore             1.000                               0.250    0.250
##    .engID            1.000                               0.398    0.398
##    .physID           1.000                               0.771    0.771
```

```
##    .mathID             1.000                                     0.840    0.840
##    .engagency          1.000                                     0.577    0.577
##     agency             1.000                                     1.000    1.000
##
## R-Square:
##                    Estimate
##     Q3Eng_f           0.653
##     Q3Eng_e           0.520
##     Q3Eng_c           0.498
##     Q3Eng_d           0.465
##     Q3Eng_h           0.683
##     Q3Eng_j           0.786
##     Q3Eng_i           0.843
##     Q3Eng_k           0.758
##     Q3Eng_l           0.677
##     Q3Eng_m           0.660
##     Q3Eng_n           0.658
##     Q12Phys_c         0.577
##     Q12Phys_d         0.677
##     Q12Phys_a         0.632
##     Q12Phys_m         0.613
##     Q12Phys_f         0.709
##     Q12Phys_g         0.885
##     Q12Phys_h         0.773
##     Q12Phys_i         0.827
##     Q12Phys_j         0.775
##     Q12Phys_k         0.789
##     Q12Phys_l         0.807
##     Q12Math_f         0.651
##     Q12Math_g         0.814
##     Q12Math_h         0.658
##     Q12Math_d         0.550
##     Q12Math_e         0.533
##     Q12Math_a         0.659
##     Q12Math_m         0.547
##     Q12Math_i         0.781
##     Q12Math_j         0.741
##     Q12Math_k         0.681
##     Q12Math_l         0.767
##     Q8f               0.650
##     Q8e               0.661
##     Q8g               0.615
##     Q8j               0.638
##     Q8b               0.594
##     Q8o               0.679
##     Q8n               0.702
##     Q8m               0.499
##     Q8l               0.646
##     Q5c               0.713
##     Q5d               0.585
```

```
##     Q5e                0.751
##     Q5g                0.712
##     Q5f                0.586
##     erec               0.425
##     eint               0.759
##     epc                0.754
##     prec               0.792
##     pint               0.788
##     ppc                0.924
##     mint               0.699
##     mrec               0.892
##     mpc                0.926
##     intent             0.661
##     fore               0.750
##     engID              0.602
##     physID             0.229
##     mathID             0.160
##     engagency          0.423
##
##
## Group 2 [0]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f (.p1.)    1.009    0.066   15.286    0.000    1.331    0.885
##     Q3Eng_e (.p2.)    0.875    0.065   13.367    0.000    1.154    0.784
##     Q3Eng_c (.p3.)    0.898    0.066   13.674    0.000    1.185    0.712
##     Q3Eng_d (.p4.)    0.845    0.072   11.769    0.000    1.114    0.699
##   eint =~
##     Q3Eng_h (.p5.)    0.462    0.048    9.580    0.000    0.940    0.872
##     Q3Eng_j (.p6.)    0.562    0.050   11.226    0.000    1.143    0.879
##     Q3Eng_i (.p7.)    0.544    0.050   10.771    0.000    1.107    0.923
##   epc =~
##     Q3Eng_k (.p8.)    0.558    0.062    9.007    0.000    1.125    0.879
##     Q3Eng_l (.p9.)    0.546    0.061    8.985    0.000    1.101    0.799
##     Q3Eng_m (.10.)    0.572    0.062    9.270    0.000    1.154    0.800
##     Q3Eng_n (.11.)    0.516    0.058    8.893    0.000    1.041    0.852
##   prec =~
##     Q12Phy_ (.12.)    0.499    0.048   10.493    0.000    1.094    0.702
##     Q12Phy_ (.13.)    0.640    0.056   11.409    0.000    1.404    0.861
##     Q12Phy_ (.14.)    0.596    0.054   11.024    0.000    1.306    0.826
##     Q12Phy_ (.15.)    0.653    0.057   11.366    0.000    1.433    0.757
##   pint =~
##     Q12Phy_ (.16.)    0.574    0.056   10.317    0.000    1.246    0.776
##     Q12Phy_ (.17.)    0.720    0.065   11.085    0.000    1.563    0.917
##     Q12Phy_ (.18.)    0.699    0.065   10.785    0.000    1.518    0.812
##   ppc =~
##     Q12Phy_ (.19.)    0.394    0.076    5.200    0.000    1.426    0.905
##     Q12Phy_ (.20.)    0.379    0.073    5.168    0.000    1.374    0.874
```

```
##     Q12Phy_ (.21.)    0.394    0.075    5.269    0.000    1.427    0.855
##     Q12Phy_ (.22.)    0.385    0.073    5.283    0.000    1.395    0.894
##   mint =~
##     Q12Mth_ (.23.)    0.657    0.065   10.076    0.000    1.198    0.821
##     Q12Mth_ (.24.)    0.732    0.068   10.791    0.000    1.334    0.941
##     Q12Mth_ (.25.)    0.681    0.063   10.891    0.000    1.241    0.815
##   mrec =~
##     Q12Mth_ (.26.)    0.376    0.071    5.311    0.000    1.143    0.777
##     Q12Mth_ (.27.)    0.363    0.068    5.316    0.000    1.103    0.778
##     Q12Mth_ (.28.)    0.369    0.069    5.350    0.000    1.121    0.840
##     Q12Mth_ (.29.)    0.414    0.078    5.338    0.000    1.259    0.790
##   mpc =~
##     Q12Mth_ (.30.)    0.328    0.078    4.195    0.000    1.206    0.878
##     Q12Mth_ (.31.)    0.327    0.078    4.192    0.000    1.202    0.887
##     Q12Mth_ (.32.)    0.328    0.078    4.217    0.000    1.206    0.873
##     Q12Mth_ (.33.)    0.322    0.074    4.338    0.000    1.182    0.937
##   intent =~
##     Q8f     (.34.)    0.664    0.072    9.184    0.000    1.140    0.879
##     Q8e     (.35.)    0.607    0.066    9.200    0.000    1.043    0.844
##     Q8g     (.36.)    0.619    0.068    9.054    0.000    1.062    0.829
##     Q8j     (.37.)    0.657    0.070    9.348    0.000    1.127    0.853
##     Q8b     (.38.)    0.571    0.066    8.590    0.000    0.980    0.788
##   fore =~
##     Q8o     (.39.)    0.476    0.055    8.676    0.000    0.953    0.806
##     Q8n     (.40.)    0.489    0.055    8.960    0.000    0.978    0.862
##     Q8m     (.41.)    0.478    0.055    8.620    0.000    0.956    0.831
##     Q8l     (.42.)    0.479    0.053    9.021    0.000    0.959    0.849
##   engID =~
##     eint    (.43.)    1.119    0.140    7.967    0.000    0.871    0.871
##     epc     (.44.)    1.105    0.177    6.239    0.000    0.868    0.868
##     erec    (.45.)    0.543    0.068    7.968    0.000    0.652    0.652
##   physID =~
##     prec    (.46.)    1.714    0.185    9.268    0.000    0.890    0.890
##     pint    (.47.)    1.692    0.196    8.644    0.000    0.888    0.888
##     ppc     (.48.)    3.055    0.632    4.837    0.000    0.961    0.961
##   mathID =~
##     mint    (.49.)    1.396    0.172    8.120    0.000    0.836    0.836
##     mrec    (.50.)    2.630    0.545    4.826    0.000    0.944    0.944
##     mpc     (.51.)    3.243    0.822    3.945    0.000    0.962    0.962
##   engagency =~
##     Q5c     (.52.)    0.689    0.052   13.135    0.000    0.907    0.870
##     Q5d     (.53.)    0.595    0.039   15.208    0.000    0.784    0.886
##     Q5e     (.54.)    0.663    0.053   12.577    0.000    0.872    0.885
##     Q5g     (.55.)    0.690    0.052   13.174    0.000    0.909    0.933
##     Q5f     (.56.)    0.705    0.055   12.850    0.000    0.928    0.897
##   agency =~
##     fore    (.57.)    1.732    0.249    6.968    0.000    0.866    0.866
##     intent  (.58.)    1.395    0.194    7.191    0.000    0.813    0.813
##
## Regressions:
```

```
##                       Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)       0.386    0.103    3.744    0.000    0.320    0.320
##     agency     (a)       0.390    0.067    5.803    0.000    0.246    0.246
##   physID ~
##     agency     (b)       0.211    0.068    3.122    0.002    0.186    0.186
##   mathID ~
##     agency     (c)       0.436    0.074    5.925    0.000    0.400    0.400
##   engagency ~
##     agency     (f)       0.677    0.109    6.186    0.000    0.515    0.515
##     mathID     (e)       0.133    0.066    2.020    0.043    0.110    0.110
##     physID     (d)       0.192    0.080    2.401    0.016    0.166    0.166
##   engID ~
##     physID     (g)       0.377    0.078    4.811    0.000    0.271    0.271
##     mathID     (h)       0.262    0.087    2.993    0.003    0.180    0.180
##   physID ~
##     mathID     (a)       0.390    0.067    5.803    0.000    0.373    0.373
##
## Intercepts:
##                       Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.132)       3.735    0.084   44.388    0.000    3.735    2.484
##    .Q3Eng_e (.133)       3.495    0.080   43.548    0.000    3.495    2.374
##    .Q3Eng_c (.134)       4.303    0.087   49.225    0.000    4.303    2.586
##    .Q3Eng_d (.135)       4.336    0.082   52.664    0.000    4.336    2.720
##    .Q3Eng_h (.136)       5.261    0.062   85.271    0.000    5.261    4.875
##    .Q3Eng_j (.137)       4.856    0.070   69.546    0.000    4.856    3.735
##    .Q3Eng_i (.138)       5.081    0.065   77.595    0.000    5.081    4.234
##    .Q3Eng_k (.139)       4.684    0.070   67.086    0.000    4.684    3.658
##    .Q3Eng_l (.140)       4.534    0.071   63.424    0.000    4.534    3.290
##    .Q3Eng_m              4.401    0.127   34.639    0.000    4.401    3.052
##    .Q3Eng_n              4.627    0.105   44.187    0.000    4.627    3.789
##    .Q12Phy_ (.143)       3.369    0.075   44.913    0.000    3.369    2.162
##    .Q12Phy_              3.729    0.136   27.430    0.000    3.729    2.287
##    .Q12Phy_              3.404    0.146   23.345    0.000    3.404    2.151
##    .Q12Phy_ (.146)       3.561    0.097   36.887    0.000    3.561    1.881
##    .Q12Phy_              5.031    0.126   40.046    0.000    5.031    3.131
##    .Q12Phy_ (.148)       4.418    0.090   48.950    0.000    4.418    2.592
##    .Q12Phy_ (.149)       4.057    0.093   43.402    0.000    4.057    2.170
##    .Q12Phy_ (.150)       4.150    0.084   49.155    0.000    4.150    2.634
##    .Q12Phy_ (.151)       4.042    0.084   47.908    0.000    4.042    2.572
##    .Q12Phy_ (.152)       3.868    0.087   44.345    0.000    3.868    2.318
##    .Q12Phy_ (.153)       4.217    0.083   50.953    0.000    4.217    2.701
##    .Q12Mth_ (.154)       4.631    0.081   57.431    0.000    4.631    3.176
##    .Q12Mth_ (.155)       4.473    0.081   55.451    0.000    4.473    3.154
##    .Q12Mth_ (.156)       4.361    0.080   54.503    0.000    4.361    2.865
##    .Q12Mth_ (.157)       4.353    0.079   55.165    0.000    4.353    2.958
##    .Q12Mth_ (.158)       4.555    0.077   58.971    0.000    4.555    3.214
##    .Q12Mth_ (.159)       4.504    0.073   62.058    0.000    4.504    3.376
##    .Q12Mth_ (.160)       4.338    0.087   49.763    0.000    4.338    2.724
##    .Q12Mth_ (.161)       4.513    0.073   61.810    0.000    4.513    3.283
```

```
##    .Q12Mth_ (.162)    4.444    0.075   59.470    0.000    4.444    3.276
##    .Q12Mth_ (.163)    4.335    0.077   56.380    0.000    4.335    3.139
##    .Q12Mth_ (.164)    4.580    0.071   64.203    0.000    4.580    3.632
##    .Q8f     (.165)    4.192    0.074   56.573    0.000    4.192    3.235
##    .Q8e     (.166)    4.400    0.068   65.138    0.000    4.400    3.561
##    .Q8g     (.167)    4.171    0.071   58.700    0.000    4.171    3.255
##    .Q8j     (.168)    3.957    0.073   54.152    0.000    3.957    2.993
##    .Q8b     (.169)    4.184    0.065   64.145    0.000    4.184    3.365
##    .Q8o     (.170)    4.634    0.062   74.586    0.000    4.634    3.922
##    .Q8n     (.171)    4.615    0.064   72.154    0.000    4.615    4.064
##    .Q8m     (.172)    4.445    0.068   65.568    0.000    4.445    3.864
##    .Q8l     (.173)    4.596    0.062   73.793    0.000    4.596    4.073
##    .Q5c     (.174)    5.010    0.059   84.882    0.000    5.010    4.807
##    .Q5d     (.175)    5.192    0.050  103.468    0.000    5.192    5.873
##    .Q5e     (.176)    5.080    0.054   94.429    0.000    5.080    5.152
##    .Q5g     (.177)    5.089    0.058   88.467    0.000    5.089    5.223
##    .Q5f     (.178)    5.002    0.061   82.367    0.000    5.002    4.835
##     erec              0.054    0.116    0.469    0.639    0.041    0.041
##     eint              0.125    0.110    1.138    0.255    0.061    0.061
##     epc              -0.453    0.127   -3.577    0.000   -0.225   -0.225
##     prec              0.041    0.154    0.263    0.792    0.019    0.019
##     pint             -0.131    0.133   -0.987    0.323   -0.060   -0.060
##     ppc              -0.148    0.096   -1.542    0.123   -0.041   -0.041
##     mint              0.289    0.123    2.342    0.019    0.158    0.158
##     mrec              0.159    0.140    1.133    0.257    0.052    0.052
##     mpc              -0.141    0.112   -1.257    0.209   -0.038   -0.038
##     intent            0.201    0.101    1.991    0.047    0.117    0.117
##     fore              0.086    0.089    0.970    0.332    0.043    0.043
##    .engID            -0.226    0.107   -2.119    0.034   -0.143   -0.143
##    .physID           -0.272    0.109   -2.495    0.013   -0.239   -0.239
##    .mathID            0.165    0.104    1.577    0.115    0.151    0.151
##    .enggncy           0.226    0.116    1.949    0.051    0.172    0.172
##     agency            0.144    0.100    1.439    0.150    0.144    0.144
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f           0.490    0.129    3.790    0.000    0.490    0.217
##    .Q3Eng_e           0.835    0.195    4.279    0.000    0.835    0.385
##    .Q3Eng_c           1.365    0.252    5.422    0.000    1.365    0.493
##    .Q3Eng_d           1.301    0.196    6.629    0.000    1.301    0.512
##    .Q3Eng_h           0.280    0.065    4.306    0.000    0.280    0.240
##    .Q3Eng_j           0.383    0.099    3.858    0.000    0.383    0.227
##    .Q3Eng_i           0.214    0.080    2.667    0.008    0.214    0.149
##    .Q3Eng_k           0.374    0.088    4.249    0.000    0.374    0.228
##    .Q3Eng_l           0.688    0.191    3.606    0.000    0.688    0.362
##    .Q3Eng_m           0.748    0.141    5.295    0.000    0.748    0.360
##    .Q3Eng_n           0.408    0.081    5.048    0.000    0.408    0.273
##    .Q12Phys_c         1.230    0.212    5.811    0.000    1.230    0.507
##    .Q12Phys_d         0.688    0.165    4.163    0.000    0.688    0.259
##    .Q12Phys_a         0.797    0.151    5.281    0.000    0.797    0.318
```

```
##    .Q12Phys_m         1.531    0.252    6.074    0.000    1.531    0.427
##    .Q12Phys_f         1.029    0.224    4.582    0.000    1.029    0.399
##    .Q12Phys_g         0.464    0.123    3.779    0.000    0.464    0.160
##    .Q12Phys_h         1.191    0.283    4.213    0.000    1.191    0.341
##    .Q12Phys_i         0.448    0.087    5.169    0.000    0.448    0.181
##    .Q12Phys_j         0.582    0.127    4.600    0.000    0.582    0.236
##    .Q12Phys_k         0.747    0.148    5.038    0.000    0.747    0.269
##    .Q12Phys_l         0.489    0.109    4.474    0.000    0.489    0.201
##    .Q12Math_f         0.691    0.167    4.147    0.000    0.691    0.325
##    .Q12Math_g         0.232    0.078    2.953    0.003    0.232    0.115
##    .Q12Math_h         0.777    0.182    4.266    0.000    0.777    0.335
##    .Q12Math_d         0.858    0.195    4.414    0.000    0.858    0.396
##    .Q12Math_e         0.792    0.190    4.158    0.000    0.792    0.394
##    .Q12Math_a         0.523    0.104    5.053    0.000    0.523    0.294
##    .Q12Math_m         0.953    0.249    3.824    0.000    0.953    0.376
##    .Q12Math_i         0.434    0.119    3.654    0.000    0.434    0.230
##    .Q12Math_j         0.394    0.097    4.069    0.000    0.394    0.214
##    .Q12Math_k         0.453    0.098    4.637    0.000    0.453    0.237
##    .Q12Math_l         0.193    0.044    4.374    0.000    0.193    0.121
##    .Q8f               0.381    0.071    5.329    0.000    0.381    0.227
##    .Q8e               0.440    0.084    5.212    0.000    0.440    0.288
##    .Q8g               0.514    0.093    5.525    0.000    0.514    0.313
##    .Q8j               0.476    0.081    5.882    0.000    0.476    0.273
##    .Q8b               0.585    0.111    5.294    0.000    0.585    0.379
##    .Q8o               0.488    0.110    4.417    0.000    0.488    0.350
##    .Q8n               0.332    0.120    2.767    0.006    0.332    0.258
##    .Q8m               0.410    0.084    4.866    0.000    0.410    0.310
##    .Q8l               0.355    0.077    4.623    0.000    0.355    0.278
##    .Q5c               0.264    0.070    3.762    0.000    0.264    0.243
##    .Q5d               0.168    0.033    5.116    0.000    0.168    0.214
##    .Q5e               0.211    0.048    4.399    0.000    0.211    0.217
##    .Q5g               0.124    0.036    3.449    0.001    0.124    0.130
##    .Q5f               0.208    0.062    3.346    0.001    0.208    0.195
##     erec              1.000                               0.575    0.575
##     eint              1.000                               0.241    0.241
##     epc               1.000                               0.246    0.246
##     prec              1.000                               0.208    0.208
##     pint              1.000                               0.212    0.212
##     ppc               1.000                               0.076    0.076
##     mint              1.000                               0.301    0.301
##     mrec              1.000                               0.108    0.108
##     mpc               1.000                               0.074    0.074
##     intent            1.000                               0.339    0.339
##     fore              1.000                               0.250    0.250
##    .engID             1.000                               0.398    0.398
##    .physID            1.000                               0.771    0.771
##    .mathID            1.000                               0.840    0.840
##    .engagency         1.000                               0.577    0.577
##     agency            1.000                               1.000    1.000
##
```

```
## R-Square:
##                    Estimate
##     Q3Eng_f           0.783
##     Q3Eng_e           0.615
##     Q3Eng_c           0.507
##     Q3Eng_d           0.488
##     Q3Eng_h           0.760
##     Q3Eng_j           0.773
##     Q3Eng_i           0.851
##     Q3Eng_k           0.772
##     Q3Eng_l           0.638
##     Q3Eng_m           0.640
##     Q3Eng_n           0.727
##     Q12Phys_c         0.493
##     Q12Phys_d         0.741
##     Q12Phys_a         0.682
##     Q12Phys_m         0.573
##     Q12Phys_f         0.601
##     Q12Phys_g         0.840
##     Q12Phys_h         0.659
##     Q12Phys_i         0.819
##     Q12Phys_j         0.764
##     Q12Phys_k         0.731
##     Q12Phys_l         0.799
##     Q12Math_f         0.675
##     Q12Math_g         0.885
##     Q12Math_h         0.665
##     Q12Math_d         0.604
##     Q12Math_e         0.606
##     Q12Math_a         0.706
##     Q12Math_m         0.624
##     Q12Math_i         0.770
##     Q12Math_j         0.786
##     Q12Math_k         0.763
##     Q12Math_l         0.879
##     Q8f               0.773
##     Q8e               0.712
##     Q8g               0.687
##     Q8j               0.727
##     Q8b               0.621
##     Q8o               0.650
##     Q8n               0.742
##     Q8m               0.690
##     Q8l               0.722
##     Q5c               0.757
##     Q5d               0.786
##     Q5e               0.783
##     Q5g               0.870
##     Q5f               0.805
##     erec              0.425
```

```
##     eint               0.759
##     epc                0.754
##     prec               0.792
##     pint               0.788
##     ppc                0.924
##     mint               0.699
##     mrec               0.892
##     mpc                0.926
##     intent             0.661
##     fore               0.750
##     engID              0.602
##     physID             0.229
##     mathID             0.160
##     engagency          0.423
##
## Defined Parameters:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     ind1              0.064    0.017    3.681    0.000    0.027    0.027
##     ind3              0.114    0.040    2.863    0.004    0.072    0.072
##     ind4              0.080    0.029    2.746    0.006    0.050    0.050
##     total             0.775    0.096    8.104    0.000    0.566    0.566


#[Model 2 versus model 3.2]
anova(fit2, fit3.2, method = "satorra.bentler.2010") #not sig


## Scaled Chi Square Difference Test (method = "satorra.bentler.2001")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit2   2095 59338 60390 4214.0
## fit3.2 2121 59311 60255 4238.3     33.265      26     0.1546


#[Model 1 versus model 3.2]
anova(fit1, fit3.2, method = "satorra.bentler.2010") #not sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2001")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit1   2027 59376 60707 4115.3
## fit3.2 2121 59311 60255 4238.3     95.066      94     0.4499


#Model 4: strict invarinace (equal loadings + intercepts + means)
fit4 <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
            missing = "listwise", estimator = "MLM",group = "Q31b",
```

```
            group.equal=c("loadings", "intercepts", "residuals"),
            group.partial = c("Q12Phys_d    ~1","Q12Phys_a~1", "Q12Phys_f~1",
                              "Q3Eng_m~1","Q3Eng_n~1"))

lavTestLRT(fit3.2, fit4, method = "satorra.bentler2010") #sig
```

```
## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit3.2 2121 59311 60255 4238.3
## fit4   2168 59432 60183 4454.1     114.69      47  1.386e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lavTestLRT(fit2, fit4, method = "satorra.bentler2010") #sig
```

```
## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##        Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit2 2095 59338 60390 4214.0
## fit4 2168 59432 60183 4454.1      152.1      73  1.678e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lavTestLRT(fit1, fit4, method = "satorra.bentler2010") #sig
```

```
## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##        Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit1 2027 59376 60707 4115.3
## fit4 2168 59432 60183 4454.1     244.29     141  1.554e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(max.print=1000000)
lavTestScore(fit4, univariate = T, epc = T)
```

```
## $test
##
## total score test:
##
##    test      X2  df p.value
```

```
## 1 score 282.201 158       0
##
## $uni
##
## univariate score tests:
##
##        lhs op    rhs     X2 df p.value
## 1    .p60. ==  .p68.  0.323  1   0.570
## 2     .p1. == .p195.  0.212  1   0.645
## 3     .p2. == .p196.  0.129  1   0.720
## 4     .p3. == .p197.  2.001  1   0.157
## 5     .p4. == .p198.  0.246  1   0.620
## 6     .p5. == .p199.  5.611  1   0.018
## 7     .p6. == .p200.  0.129  1   0.719
## 8     .p7. == .p201.  1.228  1   0.268
## 9     .p8. == .p202.  0.281  1   0.596
## 10    .p9. == .p203.  0.442  1   0.506
## 11   .p10. == .p204.  3.675  1   0.055
## 12   .p11. == .p205.  0.004  1   0.950
## 13   .p12. == .p206.  1.309  1   0.252
## 14   .p13. == .p207.  3.055  1   0.080
## 15   .p14. == .p208.  0.135  1   0.713
## 16   .p15. == .p209.  0.002  1   0.963
## 17   .p16. == .p210.  1.961  1   0.161
## 18   .p17. == .p211.  1.333  1   0.248
## 19   .p18. == .p212.  0.147  1   0.702
## 20   .p19. == .p213.  0.069  1   0.792
## 21   .p20. == .p214.  1.745  1   0.186
## 22   .p21. == .p215.  0.982  1   0.322
## 23   .p22. == .p216.  0.887  1   0.346
## 24   .p23. == .p217.  1.564  1   0.211
## 25   .p24. == .p218.  1.402  1   0.236
## 26   .p25. == .p219.  2.301  1   0.129
## 27   .p26. == .p220.  0.349  1   0.554
## 28   .p27. == .p221.  0.157  1   0.692
## 29   .p28. == .p222.  0.287  1   0.592
## 30   .p29. == .p223.  0.256  1   0.613
## 31   .p30. == .p224.  0.560  1   0.454
## 32   .p31. == .p225.  0.565  1   0.452
## 33   .p32. == .p226.  0.573  1   0.449
## 34   .p33. == .p227.  0.044  1   0.834
## 35   .p34. == .p228.  0.367  1   0.545
## 36   .p35. == .p229.  0.002  1   0.961
## 37   .p36. == .p230.  0.367  1   0.545
## 38   .p37. == .p231.  0.053  1   0.818
## 39   .p38. == .p232.  0.491  1   0.484
## 40   .p39. == .p233.  0.006  1   0.941
## 41   .p40. == .p234.  4.768  1   0.029
## 42   .p41. == .p235.  0.147  1   0.701
## 43   .p42. == .p236.  1.247  1   0.264
```

```
## 44   .p43. == .p237.  1.154  1   0.283
## 45   .p44. == .p238.  0.347  1   0.556
## 46   .p45. == .p239.  2.701  1   0.100
## 47   .p46. == .p240.  3.533  1   0.060
## 48   .p47. == .p241.  0.207  1   0.649
## 49   .p48. == .p242.  1.280  1   0.258
## 50   .p49. == .p243.  0.480  1   0.488
## 51   .p50. == .p244.  0.227  1   0.634
## 52   .p51. == .p245.  0.244  1   0.621
## 53   .p52. == .p246.  5.123  1   0.024
## 54   .p53. == .p247.  3.592  1   0.058
## 55   .p54. == .p248.  0.881  1   0.348
## 56   .p55. == .p249.  1.393  1   0.238
## 57   .p56. == .p250.  0.042  1   0.838
## 58   .p57. == .p251.  1.100  1   0.294
## 59   .p58. == .p252.  0.174  1   0.676
## 60   .p59. == .p253.  0.202  1   0.653
## 61   .p60. == .p254.  1.141  1   0.285
## 62   .p61. == .p255.  0.526  1   0.468
## 63   .p62. == .p256.  0.052  1   0.819
## 64   .p63. == .p257.  0.156  1   0.693
## 65   .p64. == .p258.  1.454  1   0.228
## 66   .p65. == .p259.  2.889  1   0.089
## 67   .p66. == .p260.  1.787  1   0.181
## 68   .p67. == .p261.  0.124  1   0.725
## 69   .p60. == .p262.  0.152  1   0.697
## 70   .p69. == .p263.  6.028  1   0.014
## 71   .p70. == .p264.  3.587  1   0.058
## 72   .p71. == .p265.  0.483  1   0.487
## 73   .p72. == .p266.  0.480  1   0.488
## 74   .p73. == .p267.  3.303  1   0.069
## 75   .p74. == .p268.  0.014  1   0.905
## 76   .p75. == .p269.  0.105  1   0.745
## 77   .p76. == .p270.  0.517  1   0.472
## 78   .p77. == .p271.  0.804  1   0.370
## 79   .p78. == .p272.  0.445  1   0.505
## 80   .p79. == .p273.  2.543  1   0.111
## 81   .p80. == .p274.  4.321  1   0.038
## 82   .p81. == .p275.  2.175  1   0.140
## 83   .p82. == .p276.  0.929  1   0.335
## 84   .p83. == .p277.  1.003  1   0.317
## 85   .p84. == .p278. 11.653  1   0.001
## 86   .p85. == .p279.  5.523  1   0.019
## 87   .p86. == .p280. 14.935  1   0.000
## 88   .p87. == .p281.  0.184  1   0.668
## 89   .p88. == .p282.  0.298  1   0.585
## 90   .p89. == .p283.  3.681  1   0.055
## 91   .p90. == .p284.  0.081  1   0.776
## 92   .p91. == .p285.  0.763  1   0.383
## 93   .p92. == .p286.  4.022  1   0.045
```

```
## 94   .p93. == .p287.  0.118  1   0.731
## 95   .p94. == .p288.  1.468  1   0.226
## 96   .p95. == .p289.  2.833  1   0.092
## 97   .p96. == .p290.  1.573  1   0.210
## 98   .p97. == .p291.  2.641  1   0.104
## 99   .p98. == .p292.  0.035  1   0.852
## 100  .p99. == .p293.  3.422  1   0.064
## 101 .p100. == .p294.  4.611  1   0.032
## 102 .p101. == .p295. 11.043  1   0.001
## 103 .p102. == .p296.  8.223  1   0.004
## 104 .p103. == .p297.  3.097  1   0.078
## 105 .p104. == .p298.  3.343  1   0.067
## 106 .p105. == .p299.  4.525  1   0.033
## 107 .p106. == .p300.  1.078  1   0.299
## 108 .p107. == .p301.  0.238  1   0.626
## 109 .p108. == .p302.  1.568  1   0.211
## 110 .p109. == .p303. 14.239  1   0.000
## 111 .p110. == .p304.  3.290  1   0.070
## 112 .p111. == .p305.  4.736  1   0.030
## 113 .p112. == .p306. 17.828  1   0.000
## 114 .p113. == .p307.  2.329  1   0.127
## 115 .p114. == .p308. 15.393  1   0.000
## 116 .p115. == .p309. 20.456  1   0.000
## 117 .p132. == .p326.  0.008  1   0.927
## 118 .p133. == .p327.  0.119  1   0.730
## 119 .p134. == .p328.  0.105  1   0.745
## 120 .p135. == .p329.  0.026  1   0.873
## 121 .p136. == .p330.  2.058  1   0.151
## 122 .p137. == .p331.  0.455  1   0.500
## 123 .p138. == .p332.  0.295  1   0.587
## 124 .p139. == .p333.  0.074  1   0.786
## 125 .p140. == .p334.  0.074  1   0.786
## 126 .p143. == .p337.  0.043  1   0.836
## 127 .p146. == .p340.  0.043  1   0.836
## 128 .p148. == .p342.  2.114  1   0.146
## 129 .p149. == .p343.  2.114  1   0.146
## 130 .p150. == .p344.  0.019  1   0.889
## 131 .p151. == .p345.  1.045  1   0.307
## 132 .p152. == .p346.  0.905  1   0.341
## 133 .p153. == .p347.  0.043  1   0.836
## 134 .p154. == .p348.  0.010  1   0.921
## 135 .p155. == .p349.  0.022  1   0.882
## 136 .p156. == .p350.  0.077  1   0.781
## 137 .p157. == .p351.  1.449  1   0.229
## 138 .p158. == .p352.  0.379  1   0.538
## 139 .p159. == .p353.  0.637  1   0.425
## 140 .p160. == .p354.  0.100  1   0.752
## 141 .p161. == .p355.  0.446  1   0.504
## 142 .p162. == .p356.  0.012  1   0.913
## 143 .p163. == .p357.  0.016  1   0.901
```

```
## 144 .p164. == .p358.  0.424  1   0.515
## 145 .p165. == .p359.  0.216  1   0.642
## 146 .p166. == .p360.  0.006  1   0.939
## 147 .p167. == .p361.  0.105  1   0.746
## 148 .p168. == .p362.  0.224  1   0.636
## 149 .p169. == .p363.  0.070  1   0.791
## 150 .p170. == .p364.  3.246  1   0.072
## 151 .p171. == .p365.  1.625  1   0.202
## 152 .p172. == .p366.  0.883  1   0.347
## 153 .p173. == .p367.  0.113  1   0.736
## 154 .p174. == .p368.  6.579  1   0.010
## 155 .p175. == .p369.  0.991  1   0.319
## 156 .p176. == .p370.  2.691  1   0.101
## 157 .p177. == .p371.  0.131  1   0.717
## 158 .p178. == .p372.  0.129  1   0.720
##
## $epc
##
## expected parameter changes (epc) and expected parameter values (epv):
##
##           lhs op       rhs group free  label plabel    est    epc    epv
## 1        erec =~   Q3Eng_f     1    1   .p1.   .p1.  0.995 -0.008  0.988
## 2        erec =~   Q3Eng_e     1    2   .p2.   .p2.  0.870 -0.016  0.854
## 3        erec =~   Q3Eng_c     1    3   .p3.   .p3.  0.902 -0.073  0.829
## 4        erec =~   Q3Eng_d     1    4   .p4.   .p4.  0.841 -0.020  0.821
## 5        eint =~   Q3Eng_h     1    5   .p5.   .p5.  0.467  0.014  0.482
## 6        eint =~   Q3Eng_j     1    6   .p6.   .p6.  0.562  0.039  0.601
## 7        eint =~   Q3Eng_i     1    7   .p7.   .p7.  0.544  0.043  0.587
## 8         epc =~   Q3Eng_k     1    8   .p8.   .p8.  0.559  0.002  0.561
## 9         epc =~   Q3Eng_l     1    9   .p9.   .p9.  0.547  0.000  0.547
## 10        epc =~   Q3Eng_m     1   10  .p10.  .p10.  0.572 -0.029  0.543
## 11        epc =~   Q3Eng_n     1   11  .p11.  .p11.  0.517 -0.001  0.515
## 12       prec =~ Q12Phys_c     1   12  .p12.  .p12.  0.493 -0.003  0.490
## 13       prec =~ Q12Phys_d     1   13  .p13.  .p13.  0.621  0.011  0.632
## 14       prec =~ Q12Phys_a     1   14  .p14.  .p14.  0.585 -0.016  0.570
## 15       prec =~ Q12Phys_m     1   15  .p15.  .p15.  0.643 -0.019  0.623
## 16       pint =~ Q12Phys_f     1   16  .p16.  .p16.  0.571 -0.024  0.547
## 17       pint =~ Q12Phys_g     1   17  .p17.  .p17.  0.727  0.000  0.727
## 18       pint =~ Q12Phys_h     1   18  .p18.  .p18.  0.700 -0.017  0.683
## 19        ppc =~ Q12Phys_i     1   19  .p19.  .p19.  0.389  0.053  0.442
## 20        ppc =~ Q12Phys_j     1   20  .p20.  .p20.  0.374  0.042  0.417
## 21        ppc =~ Q12Phys_k     1   21  .p21.  .p21.  0.388  0.044  0.432
## 22        ppc =~ Q12Phys_l     1   22  .p22.  .p22.  0.381  0.055  0.436
## 23       mint =~ Q12Math_f     1   23  .p23.  .p23.  0.659 -0.029  0.630
## 24       mint =~ Q12Math_g     1   24  .p24.  .p24.  0.735 -0.017  0.718
## 25       mint =~ Q12Math_h     1   25  .p25.  .p25.  0.678  0.006  0.684
## 26       mrec =~ Q12Math_d     1   26  .p26.  .p26.  0.360  0.046  0.406
## 27       mrec =~ Q12Math_e     1   27  .p27.  .p27.  0.348  0.044  0.391
## 28       mrec =~ Q12Math_a     1   28  .p28.  .p28.  0.354  0.044  0.398
## 29       mrec =~ Q12Math_m     1   29  .p29.  .p29.  0.398  0.041  0.439
```

```
## 30        mpc =~ Q12Math_i     1    30  .p30.  .p30. 0.334  0.037  0.371
## 31        mpc =~ Q12Math_j     1    31  .p31.  .p31. 0.334  0.031  0.365
## 32        mpc =~ Q12Math_k     1    32  .p32.  .p32. 0.335  0.031  0.366
## 33        mpc =~ Q12Math_l     1    33  .p33.  .p33. 0.325  0.037  0.362
## 34     intent =~       Q8f     1    34  .p34.  .p34. 0.663 -0.028  0.636
## 35     intent =~       Q8e     1    35  .p35.  .p35. 0.608 -0.022  0.586
## 36     intent =~       Q8g     1    36  .p36.  .p36. 0.619 -0.030  0.589
## 37     intent =~       Q8j     1    37  .p37.  .p37. 0.652 -0.019  0.633
## 38     intent =~       Q8b     1    38  .p38.  .p38. 0.570 -0.013  0.557
## 39       fore =~       Q8o     1    39  .p39.  .p39. 0.482 -0.009  0.473
## 40       fore =~       Q8n     1    40  .p40.  .p40. 0.501 -0.022  0.478
## 41       fore =~       Q8m     1    41  .p41.  .p41. 0.485 -0.002  0.484
## 42       fore =~       Q8l     1    42  .p42.  .p42. 0.482  0.010  0.492
## 43     engID =~      eint     1    43  .p43.  .p43. 1.110 -0.105  1.005
## 44     engID =~       epc     1    44  .p44.  .p44. 1.095  0.006  1.101
## 45     engID =~      erec     1    45  .p45.  .p45. 0.541  0.055  0.596
## 46    physID =~      prec     1    46  .p46.  .p46. 1.752  0.047  1.799
## 47    physID =~      pint     1    47  .p47.  .p47. 1.681 -0.019  1.663
## 48    physID =~       ppc     1    48  .p48.  .p48. 3.100 -0.516  2.584
## 49    mathID =~      mint     1    49  .p49.  .p49. 1.399 -0.002  1.397
## 50    mathID =~      mrec     1    50  .p50.  .p50. 2.750 -0.358  2.391
## 51    mathID =~       mpc     1    51  .p51.  .p51. 3.183 -0.397  2.786
## 52 engagency =~       Q5c     1    52  .p52.  .p52. 0.698 -0.031  0.668
## 53 engagency =~       Q5d     1    53  .p53.  .p53. 0.569  0.025  0.594
## 54 engagency =~       Q5e     1    54  .p54.  .p54. 0.661  0.003  0.664
## 55 engagency =~       Q5g     1    55  .p55.  .p55. 0.694 -0.013  0.682
## 56 engagency =~       Q5f     1    56  .p56.  .p56. 0.694  0.004  0.699
## 57    agency =~      fore     1    57  .p57.  .p57. 1.700 -0.030  1.669
## 58    agency =~    intent     1    58  .p58.  .p58. 1.401  0.057  1.458
## 59     engID  ~ engagency     1    59      i  .p59. 0.400 -0.004  0.396
## 60     engID  ~    agency     1    60      a  .p60. 0.388 -0.003  0.385
## 61    physID  ~    agency     1    61      b  .p61. 0.209 -0.031  0.178
## 62    mathID  ~    agency     1    62      c  .p62. 0.435 -0.001  0.434
## 63 engagency  ~    agency     1    63      f  .p63. 0.676  0.012  0.688
## 64 engagency  ~    mathID     1    64      e  .p64. 0.137 -0.022  0.115
## 65 engagency  ~    physID     1    65      d  .p65. 0.194 -0.041  0.153
## 66     engID  ~    physID     1    66      g  .p66. 0.375 -0.048  0.328
## 67     engID  ~    mathID     1    67      h  .p67. 0.263  0.009  0.273
## 68    physID  ~    mathID     1    68      a  .p68. 0.388  0.039  0.427
## 69   Q3Eng_f ~~   Q3Eng_f     1    69  .p69.  .p69. 0.838 -0.123  0.715
## 70   Q3Eng_e ~~   Q3Eng_e     1    70  .p70.  .p70. 1.134 -0.089  1.045
## 71   Q3Eng_c ~~   Q3Eng_c     1    71  .p71.  .p71. 1.390  0.008  1.398
## 72   Q3Eng_d ~~   Q3Eng_d     1    72  .p72.  .p72. 1.403 -0.029  1.374
## 73   Q3Eng_h ~~   Q3Eng_h     1    73  .p73.  .p73. 0.375 -0.024  0.351
## 74   Q3Eng_j ~~   Q3Eng_j     1    74  .p74.  .p74. 0.361  0.005  0.366
## 75   Q3Eng_i ~~   Q3Eng_i     1    75  .p75.  .p75. 0.226 -0.011  0.215
## 76   Q3Eng_k ~~   Q3Eng_k     1    76  .p76.  .p76. 0.397 -0.021  0.376
## 77   Q3Eng_l ~~   Q3Eng_l     1    77  .p77.  .p77. 0.606  0.025  0.631
## 78   Q3Eng_m ~~   Q3Eng_m     1    78  .p78.  .p78. 0.703  0.038  0.741
## 79   Q3Eng_n ~~   Q3Eng_n     1    79  .p79.  .p79. 0.524 -0.041  0.483
```

```
## 80  Q12Phys_c ~~ Q12Phys_c     1   80  .p80.  .p80.  0.964  0.087  1.051
## 81  Q12Phys_d ~~ Q12Phys_d     1   81  .p81.  .p81.  0.902 -0.088  0.814
## 82  Q12Phys_a ~~ Q12Phys_a     1   82  .p82.  .p82.  0.950 -0.037  0.913
## 83  Q12Phys_m ~~ Q12Phys_m     1   83  .p83.  .p83.  1.351  0.073  1.424
## 84  Q12Phys_f ~~ Q12Phys_f     1   84  .p84.  .p84.  0.741  0.112  0.854
## 85  Q12Phys_g ~~ Q12Phys_g     1   85  .p85.  .p85.  0.346  0.014  0.360
## 86  Q12Phys_h ~~ Q12Phys_h     1   86  .p86.  .p86.  0.806  0.142  0.948
## 87  Q12Phys_i ~~ Q12Phys_i     1   87  .p87.  .p87.  0.431  0.002  0.433
## 88  Q12Phys_j ~~ Q12Phys_j     1   88  .p88.  .p88.  0.559  0.015  0.574
## 89  Q12Phys_k ~~ Q12Phys_k     1   89  .p89.  .p89.  0.594  0.054  0.649
## 90  Q12Phys_l ~~ Q12Phys_l     1   90  .p90.  .p90.  0.469 -0.003  0.466
## 91  Q12Math_f ~~ Q12Math_f     1   91  .p91.  .p91.  0.746 -0.011  0.736
## 92  Q12Math_g ~~ Q12Math_g     1   92  .p92.  .p92.  0.357 -0.041  0.317
## 93  Q12Math_h ~~ Q12Math_h     1   93  .p93.  .p93.  0.806 -0.013  0.793
## 94  Q12Math_d ~~ Q12Math_d     1   94  .p94.  .p94.  1.021 -0.061  0.959
## 95  Q12Math_e ~~ Q12Math_e     1   95  .p95.  .p95.  1.000 -0.079  0.921
## 96  Q12Math_a ~~ Q12Math_a     1   96  .p96.  .p96.  0.623 -0.046  0.578
## 97  Q12Math_m ~~ Q12Math_m     1   97  .p97.  .p97.  1.231 -0.087  1.144
## 98  Q12Math_i ~~ Q12Math_i     1   98  .p98.  .p98.  0.414  0.001  0.415
## 99  Q12Math_j ~~ Q12Math_j     1   99  .p99.  .p99.  0.477 -0.035  0.442
## 100 Q12Math_k ~~ Q12Math_k     1  100 .p100. .p100.  0.621 -0.053  0.568
## 101 Q12Math_l ~~ Q12Math_l     1  101 .p101. .p101.  0.369 -0.061  0.308
## 102       Q8f ~~       Q8f     1  102 .p102. .p102.  0.620 -0.073  0.547
## 103       Q8e ~~       Q8e     1  103 .p103. .p103.  0.522 -0.034  0.488
## 104       Q8g ~~       Q8g     1  104 .p104. .p104.  0.658 -0.042  0.616
## 105       Q8j ~~       Q8j     1  105 .p105. .p105.  0.664 -0.058  0.606
## 106       Q8b ~~       Q8b     1  106 .p106. .p106.  0.636 -0.025  0.612
## 107       Q8o ~~       Q8o     1  107 .p107. .p107.  0.449  0.020  0.469
## 108       Q8n ~~       Q8n     1  108 .p108. .p108.  0.381 -0.006  0.375
## 109       Q8m ~~       Q8m     1  109 .p109. .p109.  0.788 -0.129  0.660
## 110       Q8l ~~       Q8l     1  110 .p110. .p110.  0.469 -0.047  0.422
## 111       Q5c ~~       Q5c     1  111 .p111. .p111.  0.303 -0.016  0.287
## 112       Q5d ~~       Q5d     1  112 .p112. .p112.  0.373 -0.069  0.305
## 113       Q5e ~~       Q5e     1  113 .p113. .p113.  0.241 -0.012  0.229
## 114       Q5g ~~       Q5g     1  114 .p114. .p114.  0.285 -0.046  0.239
## 115       Q5f ~~       Q5f     1  115 .p115. .p115.  0.516 -0.097  0.419
## 116      erec ~~      erec     1    0        .p116.     NA     NA     NA
## 117      eint ~~      eint     1    0        .p117.     NA     NA     NA
## 118       epc ~~       epc     1    0        .p118.     NA     NA     NA
## 119      prec ~~      prec     1    0        .p119.     NA     NA     NA
## 120      pint ~~      pint     1    0        .p120.     NA     NA     NA
## 121       ppc ~~       ppc     1    0        .p121.     NA     NA     NA
## 122      mint ~~      mint     1    0        .p122.     NA     NA     NA
## 123      mrec ~~      mrec     1    0        .p123.     NA     NA     NA
## 124       mpc ~~       mpc     1    0        .p124.     NA     NA     NA
## 125    intent ~~    intent     1    0        .p125.     NA     NA     NA
## 126      fore ~~      fore     1    0        .p126.     NA     NA     NA
## 127    engID ~~     engID     1    0        .p127.     NA     NA     NA
## 128    physID ~~    physID     1    0        .p128.     NA     NA     NA
## 129    mathID ~~    mathID     1    0        .p129.     NA     NA     NA
```

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## 130 engagency ~~ engagency     1    0        .p130.      NA      NA      NA
## 131    agency ~~    agency     1    0        .p131.      NA      NA      NA
## 132   Q3Eng_f ~1               1  116 .p132. .p132.   3.735 -0.002  3.733
## 133   Q3Eng_e ~1               1  117 .p133. .p133.   3.497 -0.009  3.488
## 134   Q3Eng_c ~1               1  118 .p134. .p134.   4.302  0.009  4.311
## 135   Q3Eng_d ~1               1  119 .p135. .p135.   4.335  0.005  4.340
## 136   Q3Eng_h ~1               1  120 .p136. .p136.   5.255  0.021  5.276
## 137   Q3Eng_j ~1               1  121 .p137. .p137.   4.856 -0.009  4.847
## 138   Q3Eng_i ~1               1  122 .p138. .p138.   5.083 -0.005  5.078
## 139   Q3Eng_k ~1               1  123 .p139. .p139.   4.684  0.003  4.687
## 140   Q3Eng_l ~1               1  124 .p140. .p140.   4.534 -0.004  4.529
## 141   Q3Eng_m ~1               1  125        .p141.   4.143  0.000  4.143
## 142   Q3Eng_n ~1               1  126        .p142.   4.406  0.000  4.406
## 143 Q12Phys_c ~1               1  127 .p143. .p143.   3.370  0.004  3.374
## 144 Q12Phys_d ~1               1  128        .p144.   3.591  0.000  3.591
## 145 Q12Phys_a ~1               1  129        .p145.   3.673  0.000  3.673
## 146 Q12Phys_m ~1               1  130 .p146. .p146.   3.560 -0.004  3.556
## 147 Q12Phys_f ~1               1  131        .p147.   4.751  0.000  4.751
## 148 Q12Phys_g ~1               1  132 .p148. .p148.   4.422  0.012  4.434
## 149 Q12Phys_h ~1               1  133 .p149. .p149.   4.046 -0.030  4.017
## 150 Q12Phys_i ~1               1  134 .p150. .p150.   4.150 -0.002  4.148
## 151 Q12Phys_j ~1               1  135 .p151. .p151.   4.040 -0.018  4.022
## 152 Q12Phys_k ~1               1  136 .p152. .p152.   3.871  0.017  3.889
## 153 Q12Phys_l ~1               1  137 .p153. .p153.   4.217  0.003  4.220
## 154 Q12Math_f ~1               1  138 .p154. .p154.   4.631  0.002  4.633
## 155 Q12Math_g ~1               1  139 .p155. .p155.   4.472  0.002  4.474
## 156 Q12Math_h ~1               1  140 .p156. .p156.   4.362 -0.006  4.357
## 157 Q12Math_d ~1               1  141 .p157. .p157.   4.348  0.029  4.376
## 158 Q12Math_e ~1               1  142 .p158. .p158.   4.558 -0.015  4.544
## 159 Q12Math_a ~1               1  143 .p159. .p159.   4.507 -0.014  4.493
## 160 Q12Math_m ~1               1  144 .p160. .p160.   4.336  0.008  4.344
## 161 Q12Math_i ~1               1  145 .p161. .p161.   4.514 -0.010  4.504
## 162 Q12Math_j ~1               1  146 .p162. .p162.   4.446 -0.002  4.444
## 163 Q12Math_k ~1               1  147 .p163. .p163.   4.336  0.002  4.338
## 164 Q12Math_l ~1               1  148 .p164. .p164.   4.576  0.009  4.585
## 165       Q8f ~1               1  149 .p165. .p165.   4.196 -0.009  4.187
## 166       Q8e ~1               1  150 .p166. .p166.   4.399  0.001  4.400
## 167       Q8g ~1               1  151 .p167. .p167.   4.172 -0.006  4.166
## 168       Q8j ~1               1  152 .p168. .p168.   3.954  0.009  3.963
## 169       Q8b ~1               1  153 .p169. .p169.   4.184  0.005  4.189
## 170       Q8o ~1               1  154 .p170. .p170.   4.633 -0.028  4.605
## 171       Q8n ~1               1  155 .p171. .p171.   4.614  0.017  4.631
## 172       Q8m ~1               1  156 .p172. .p172.   4.433  0.021  4.454
## 173       Q8l ~1               1  157 .p173. .p173.   4.600 -0.005  4.595
## 174       Q5c ~1               1  158 .p174. .p174.   5.001  0.033  5.034
## 175       Q5d ~1               1  159 .p175. .p175.   5.207 -0.015  5.192
## 176       Q5e ~1               1  160 .p176. .p176.   5.081 -0.019  5.062
## 177       Q5g ~1               1  161 .p177. .p177.   5.089 -0.005  5.085
## 178       Q5f ~1               1  162 .p178. .p178.   4.995  0.006  5.001
## 179      erec ~1               1    0        .p179.      NA      NA      NA
```

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## 180      eint ~1               1   0       .p180.    NA     NA     NA
## 181       epc ~1               1   0       .p181.    NA     NA     NA
## 182      prec ~1               1   0       .p182.    NA     NA     NA
## 183      pint ~1               1   0       .p183.    NA     NA     NA
## 184       ppc ~1               1   0       .p184.    NA     NA     NA
## 185      mint ~1               1   0       .p185.    NA     NA     NA
## 186      mrec ~1               1   0       .p186.    NA     NA     NA
## 187       mpc ~1               1   0       .p187.    NA     NA     NA
## 188    intent ~1               1   0       .p188.    NA     NA     NA
## 189      fore ~1               1   0       .p189.    NA     NA     NA
## 190     engID ~1               1   0       .p190.    NA     NA     NA
## 191    physID ~1               1   0       .p191.    NA     NA     NA
## 192    mathID ~1               1   0       .p192.    NA     NA     NA
## 193 engagency ~1               1   0       .p193.    NA     NA     NA
## 194    agency ~1               1   0       .p194.    NA     NA     NA
## 195      erec =~   Q3Eng_f     2 163   .p1. .p195. 0.995  0.022  1.018
## 196      erec =~   Q3Eng_e     2 164   .p2. .p196. 0.870  0.048  0.918
## 197      erec =~   Q3Eng_c     2 165   .p3. .p197. 0.902  0.219  1.121
## 198      erec =~   Q3Eng_d     2 166   .p4. .p198. 0.841  0.059  0.899
## 199      eint =~   Q3Eng_h     2 167   .p5. .p199. 0.467 -0.047  0.420
## 200      eint =~   Q3Eng_j     2 168   .p6. .p200. 0.562 -0.123  0.440
## 201      eint =~   Q3Eng_i     2 169   .p7. .p201. 0.544 -0.137  0.407
## 202       epc =~   Q3Eng_k     2 170   .p8. .p202. 0.559 -0.012  0.547
## 203       epc =~   Q3Eng_l     2 171   .p9. .p203. 0.547 -0.002  0.545
## 204       epc =~   Q3Eng_m     2 172  .p10. .p204. 0.572  0.081  0.653
## 205       epc =~   Q3Eng_n     2 173  .p11. .p205. 0.517  0.000  0.516
## 206      prec =~ Q12Phys_c     2 174  .p12. .p206. 0.493  0.007  0.500
## 207      prec =~ Q12Phys_d     2 175  .p13. .p207. 0.621 -0.033  0.587
## 208      prec =~ Q12Phys_a     2 176  .p14. .p208. 0.585  0.046  0.632
## 209      prec =~ Q12Phys_m     2 177  .p15. .p209. 0.643  0.059  0.702
## 210      pint =~ Q12Phys_f     2 178  .p16. .p210. 0.571  0.071  0.643
## 211      pint =~ Q12Phys_g     2 179  .p17. .p211. 0.727 -0.006  0.720
## 212      pint =~ Q12Phys_h     2 180  .p18. .p212. 0.700  0.058  0.758
## 213       ppc =~ Q12Phys_i     2 181  .p19. .p213. 0.389 -0.154  0.235
## 214       ppc =~ Q12Phys_j     2 182  .p20. .p214. 0.374 -0.120  0.254
## 215       ppc =~ Q12Phys_k     2 183  .p21. .p215. 0.388 -0.132  0.256
## 216       ppc =~ Q12Phys_l     2 184  .p22. .p216. 0.381 -0.162  0.219
## 217      mint =~ Q12Math_f     2 185  .p23. .p217. 0.659  0.089  0.748
## 218      mint =~ Q12Math_g     2 186  .p24. .p218. 0.735  0.052  0.786
## 219      mint =~ Q12Math_h     2 187  .p25. .p219. 0.678 -0.023  0.655
## 220      mrec =~ Q12Math_d     2 188  .p26. .p220. 0.360 -0.131  0.229
## 221      mrec =~ Q12Math_e     2 189  .p27. .p221. 0.348 -0.136  0.212
## 222      mrec =~ Q12Math_a     2 190  .p28. .p222. 0.354 -0.137  0.217
## 223      mrec =~ Q12Math_m     2 191  .p29. .p223. 0.398 -0.121  0.277
## 224       mpc =~ Q12Math_i     2 192  .p30. .p224. 0.334 -0.107  0.227
## 225       mpc =~ Q12Math_j     2 193  .p31. .p225. 0.334 -0.089  0.245
## 226       mpc =~ Q12Math_k     2 194  .p32. .p226. 0.335 -0.087  0.248
## 227       mpc =~ Q12Math_l     2 195  .p33. .p227. 0.325 -0.104  0.221
## 228    intent =~       Q8f     2 196  .p34. .p228. 0.663  0.073  0.736
## 229    intent =~       Q8e     2 197  .p35. .p229. 0.608  0.062  0.670
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## 230    intent =~       Q8g      2  198  .p36. .p230.  0.619  0.081  0.700
## 231    intent =~       Q8j      2  199  .p37. .p231.  0.652  0.056  0.708
## 232    intent =~       Q8b      2  200  .p38. .p232.  0.570  0.037  0.607
## 233      fore =~       Q8o      2  201  .p39. .p233.  0.482 -0.002  0.480
## 234      fore =~       Q8n      2  202  .p40. .p234.  0.501  0.052  0.552
## 235      fore =~       Q8m      2  203  .p41. .p235.  0.485 -0.010  0.475
## 236      fore =~       Q8l      2  204  .p42. .p236.  0.482 -0.051  0.431
## 237     engID =~      eint      2  205  .p43. .p237.  1.110  0.404  1.514
## 238     engID =~       epc      2  206  .p44. .p238.  1.095  0.065  1.160
## 239     engID =~      erec      2  207  .p45. .p239.  0.541 -0.130  0.411
## 240    physID =~      prec      2  208  .p46. .p240.  1.752 -0.180  1.572
## 241    physID =~      pint      2  209  .p47. .p241.  1.681  0.021  1.703
## 242    physID =~       ppc      2  210  .p48. .p242.  3.100  1.437  4.537
## 243    mathID =~      mint      2  211  .p49. .p243.  1.399  0.038  1.436
## 244    mathID =~      mrec      2  212  .p50. .p244.  2.750  1.146  3.895
## 245    mathID =~       mpc      2  213  .p51. .p245.  3.183  1.221  4.404
## 246 engagency =~       Q5c      2  214  .p52. .p246.  0.698  0.117  0.815
## 247 engagency =~       Q5d      2  215  .p53. .p247.  0.569 -0.081  0.489
## 248 engagency =~       Q5e      2  216  .p54. .p248.  0.661 -0.018  0.644
## 249 engagency =~       Q5g      2  217  .p55. .p249.  0.694  0.038  0.733
## 250 engagency =~       Q5f      2  218  .p56. .p250.  0.694 -0.005  0.690
## 251    agency =~      fore      2  219  .p57. .p251.  1.700  0.159  1.859
## 252    agency =~    intent      2  220  .p58. .p252.  1.401 -0.178  1.223
## 253     engID  ~ engagency      2  221      i .p253.  0.400  0.145  0.545
## 254     engID  ~    agency      2  222      a .p254.  0.388 -0.394 -0.006
## 255    physID  ~    agency      2  223      b .p255.  0.209  0.033  0.242
## 256    mathID  ~    agency      2  224      c .p256.  0.435 -0.031  0.404
## 257 engagency  ~    agency      2  225      f .p257.  0.676 -0.065  0.611
## 258 engagency  ~    mathID      2  226      e .p258.  0.137  0.079  0.216
## 259 engagency  ~    physID      2  227      d .p259.  0.194  0.125  0.319
## 260     engID  ~    physID      2  228      g .p260.  0.375  0.124  0.499
## 261     engID  ~    mathID      2  229      h .p261.  0.263  0.019  0.282
## 262    physID  ~    mathID      2  230      a .p262.  0.388  0.019  0.407
## 263   Q3Eng_f ~~   Q3Eng_f      2  231  .p69. .p263.  0.838  0.368  1.206
## 264   Q3Eng_e ~~   Q3Eng_e      2  232  .p70. .p264.  1.134  0.267  1.401
## 265   Q3Eng_c ~~   Q3Eng_c      2  233  .p71. .p265.  1.390 -0.025  1.365
## 266   Q3Eng_d ~~   Q3Eng_d      2  234  .p72. .p266.  1.403  0.087  1.490
## 267   Q3Eng_h ~~   Q3Eng_h      2  235  .p73. .p267.  0.375  0.072  0.448
## 268   Q3Eng_j ~~   Q3Eng_j      2  236  .p74. .p268.  0.361 -0.015  0.346
## 269   Q3Eng_i ~~   Q3Eng_i      2  237  .p75. .p269.  0.226  0.034  0.260
## 270   Q3Eng_k ~~   Q3Eng_k      2  238  .p76. .p270.  0.397  0.063  0.460
## 271   Q3Eng_l ~~   Q3Eng_l      2  239  .p77. .p271.  0.606 -0.077  0.529
## 272   Q3Eng_m ~~   Q3Eng_m      2  240  .p78. .p272.  0.703 -0.113  0.590
## 273   Q3Eng_n ~~   Q3Eng_n      2  241  .p79. .p273.  0.524  0.123  0.647
## 274 Q12Phys_c ~~ Q12Phys_c      2  242  .p80. .p274.  0.964 -0.260  0.704
## 275 Q12Phys_d ~~ Q12Phys_d      2  243  .p81. .p275.  0.902  0.263  1.165
## 276 Q12Phys_a ~~ Q12Phys_a      2  244  .p82. .p276.  0.950  0.111  1.061
## 277 Q12Phys_m ~~ Q12Phys_m      2  245  .p83. .p277.  1.351 -0.219  1.133
## 278 Q12Phys_f ~~ Q12Phys_f      2  246  .p84. .p278.  0.741 -0.339  0.403
## 279 Q12Phys_g ~~ Q12Phys_g      2  247  .p85. .p279.  0.346 -0.035  0.311
```

```
## 280 Q12Phys_h ~~ Q12Phys_h     2  248  .p86. .p280.  0.806 -0.434  0.372
## 281 Q12Phys_i ~~ Q12Phys_i     2  249  .p87. .p281.  0.431 -0.006  0.425
## 282 Q12Phys_j ~~ Q12Phys_j     2  250  .p88. .p282.  0.559 -0.046  0.513
## 283 Q12Phys_k ~~ Q12Phys_k     2  251  .p89. .p283.  0.594 -0.161  0.433
## 284 Q12Phys_l ~~ Q12Phys_l     2  252  .p90. .p284.  0.469  0.010  0.480
## 285 Q12Math_f ~~ Q12Math_f     2  253  .p91. .p285.  0.746  0.032  0.779
## 286 Q12Math_g ~~ Q12Math_g     2  254  .p92. .p286.  0.357  0.120  0.477
## 287 Q12Math_h ~~ Q12Math_h     2  255  .p93. .p287.  0.806  0.042  0.848
## 288 Q12Math_d ~~ Q12Math_d     2  256  .p94. .p288.  1.021  0.177  1.198
## 289 Q12Math_e ~~ Q12Math_e     2  257  .p95. .p289.  1.000  0.241  1.241
## 290 Q12Math_a ~~ Q12Math_a     2  258  .p96. .p290.  0.623  0.141  0.764
## 291 Q12Math_m ~~ Q12Math_m     2  259  .p97. .p291.  1.231  0.259  1.490
## 292 Q12Math_i ~~ Q12Math_i     2  260  .p98. .p292.  0.414  0.000  0.414
## 293 Q12Math_j ~~ Q12Math_j     2  261  .p99. .p293.  0.477  0.104  0.581
## 294 Q12Math_k ~~ Q12Math_k     2  262 .p100. .p294.  0.621  0.158  0.779
## 295 Q12Math_l ~~ Q12Math_l     2  263 .p101. .p295.  0.369  0.183  0.552
## 296       Q8f ~~       Q8f     2  264 .p102. .p296.  0.620  0.222  0.842
## 297       Q8e ~~       Q8e     2  265 .p103. .p297.  0.522  0.103  0.625
## 298       Q8g ~~       Q8g     2  266 .p104. .p298.  0.658  0.129  0.787
## 299       Q8j ~~       Q8j     2  267 .p105. .p299.  0.664  0.172  0.837
## 300       Q8b ~~       Q8b     2  268 .p106. .p300.  0.636  0.073  0.709
## 301       Q8o ~~       Q8o     2  269 .p107. .p301.  0.449 -0.054  0.395
## 302       Q8n ~~       Q8n     2  270 .p108. .p302.  0.381  0.013  0.393
## 303       Q8m ~~       Q8m     2  271 .p109. .p303.  0.788  0.383  1.171
## 304       Q8l ~~       Q8l     2  272 .p110. .p304.  0.469  0.142  0.611
## 305       Q5c ~~       Q5c     2  273 .p111. .p305.  0.303  0.042  0.344
## 306       Q5d ~~       Q5d     2  274 .p112. .p306.  0.373  0.208  0.582
## 307       Q5e ~~       Q5e     2  275 .p113. .p307.  0.241  0.041  0.282
## 308       Q5g ~~       Q5g     2  276 .p114. .p308.  0.285  0.139  0.424
## 309       Q5f ~~       Q5f     2  277 .p115. .p309.  0.516  0.291  0.807
## 310      erec ~~      erec     2    0        .p310.     NA     NA     NA
## 311      eint ~~      eint     2    0        .p311.     NA     NA     NA
## 312       epc ~~       epc     2    0        .p312.     NA     NA     NA
## 313      prec ~~      prec     2    0        .p313.     NA     NA     NA
## 314      pint ~~      pint     2    0        .p314.     NA     NA     NA
## 315       ppc ~~       ppc     2    0        .p315.     NA     NA     NA
## 316      mint ~~      mint     2    0        .p316.     NA     NA     NA
## 317      mrec ~~      mrec     2    0        .p317.     NA     NA     NA
## 318       mpc ~~       mpc     2    0        .p318.     NA     NA     NA
## 319    intent ~~    intent     2    0        .p319.     NA     NA     NA
## 320      fore ~~      fore     2    0        .p320.     NA     NA     NA
## 321     engID ~~     engID     2    0        .p321.     NA     NA     NA
## 322    physID ~~    physID     2    0        .p322.     NA     NA     NA
## 323    mathID ~~    mathID     2    0        .p323.     NA     NA     NA
## 324 engagency ~~ engagency     2    0        .p324.     NA     NA     NA
## 325    agency ~~    agency     2    0        .p325.     NA     NA     NA
## 326   Q3Eng_f ~1               2  278 .p132. .p326.  3.735  0.009  3.744
## 327   Q3Eng_e ~1               2  279 .p133. .p327.  3.497  0.028  3.525
## 328   Q3Eng_c ~1               2  280 .p134. .p328.  4.302 -0.031  4.270
## 329   Q3Eng_d ~1               2  281 .p135. .p329.  4.335 -0.012  4.323
```

```
## 330   Q3Eng_h ~1                2  282 .p136. .p330.  5.255 -0.056  5.199
## 331   Q3Eng_j ~1                2  283 .p137. .p331.  4.856  0.041  4.897
## 332   Q3Eng_i ~1                2  284 .p138. .p332.  5.083  0.030  5.112
## 333   Q3Eng_k ~1                2  285 .p139. .p333.  4.684 -0.018  4.666
## 334   Q3Eng_l ~1                2  286 .p140. .p334.  4.534  0.009  4.543
## 335   Q3Eng_m ~1                2  287        .p335.  4.401  0.038  4.438
## 336   Q3Eng_n ~1                2  288        .p336.  4.628 -0.003  4.624
## 337 Q12Phys_c ~1                2  289 .p143. .p337.  3.370 -0.020  3.349
## 338 Q12Phys_d ~1                2  290        .p338.  3.726 -0.019  3.707
## 339 Q12Phys_a ~1                2  291        .p339.  3.402 -0.001  3.401
## 340 Q12Phys_m ~1                2  292 .p146. .p340.  3.560  0.014  3.574
## 341 Q12Phys_f ~1                2  293        .p341.  5.030  0.011  5.041
## 342 Q12Phys_g ~1                2  294 .p148. .p342.  4.422 -0.060  4.361
## 343 Q12Phys_h ~1                2  295 .p149. .p343.  4.046  0.091  4.138
## 344 Q12Phys_i ~1                2  296 .p150. .p344.  4.150 -0.005  4.145
## 345 Q12Phys_j ~1                2  297 .p151. .p345.  4.040  0.061  4.101
## 346 Q12Phys_k ~1                2  298 .p152. .p346.  3.871 -0.050  3.821
## 347 Q12Phys_l ~1                2  299 .p153. .p347.  4.217 -0.028  4.189
## 348 Q12Math_f ~1                2  300 .p154. .p348.  4.631 -0.044  4.587
## 349 Q12Math_g ~1                2  301 .p155. .p349.  4.472 -0.018  4.454
## 350 Q12Math_h ~1                2  302 .p156. .p350.  4.362  0.048  4.411
## 351 Q12Math_d ~1                2  303 .p157. .p351.  4.348 -0.066  4.282
## 352 Q12Math_e ~1                2  304 .p158. .p352.  4.558  0.071  4.630
## 353 Q12Math_a ~1                2  305 .p159. .p353.  4.507  0.068  4.575
## 354 Q12Math_m ~1                2  306 .p160. .p354.  4.336 -0.021  4.315
## 355 Q12Math_i ~1                2  307 .p161. .p355.  4.514  0.022  4.535
## 356 Q12Math_j ~1                2  308 .p162. .p356.  4.446 -0.012  4.433
## 357 Q12Math_k ~1                2  309 .p163. .p357.  4.336 -0.026  4.310
## 358 Q12Math_l ~1                2  310 .p164. .p358.  4.576 -0.034  4.542
## 359       Q8f ~1                2  311 .p165. .p359.  4.196  0.022  4.218
## 360       Q8e ~1                2  312 .p166. .p360.  4.399 -0.005  4.394
## 361       Q8g ~1                2  313 .p167. .p361.  4.172  0.010  4.182
## 362       Q8j ~1                2  314 .p168. .p362.  3.954 -0.025  3.929
## 363       Q8b ~1                2  315 .p169. .p363.  4.184 -0.008  4.175
## 364       Q8o ~1                2  316 .p170. .p364.  4.633  0.083  4.716
## 365       Q8n ~1                2  317 .p171. .p365.  4.614 -0.069  4.544
## 366       Q8m ~1                2  318 .p172. .p366.  4.433 -0.060  4.373
## 367       Q8l ~1                2  319 .p173. .p367.  4.600  0.031  4.631
## 368       Q5c ~1                2  320 .p174. .p368.  5.001 -0.132  4.869
## 369       Q5d ~1                2  321 .p175. .p369.  5.207  0.078  5.285
## 370       Q5e ~1                2  322 .p176. .p370.  5.081  0.068  5.149
## 371       Q5g ~1                2  323 .p177. .p371.  5.089  0.008  5.097
## 372       Q5f ~1                2  324 .p178. .p372.  4.995 -0.011  4.984
## 373      erec ~1                2  325        .p373.  0.054 -0.006  0.048
## 374      eint ~1                2  326        .p374.  0.111  0.013  0.124
## 375       epc ~1                2  327        .p375. -0.460  0.015 -0.446
## 376      prec ~1                2  328        .p376.  0.040 -0.014  0.027
## 377      pint ~1                2  329        .p377. -0.137  0.026 -0.110
## 378       ppc ~1                2  330        .p378. -0.151 -0.009 -0.161
## 379      mint ~1                2  331        .p379.  0.287 -0.009  0.278
```

```
## 380      mrec ~1                2  332        .p380.  0.167  0.017  0.184
## 381       mpc ~1                2  333        .p381. -0.150 -0.017 -0.166
## 382    intent ~1                2  334        .p382.  0.201 -0.003  0.198
## 383      fore ~1                2  335        .p383.  0.070 -0.009  0.061
## 384     engID ~1                2  336        .p384. -0.231  0.027 -0.203
## 385    physID ~1                2  337        .p385. -0.269  0.003 -0.266
## 386    mathID ~1                2  338        .p386.  0.164 -0.010  0.154
## 387 engagency ~1                2  339        .p387.  0.233  0.007  0.240
## 388    agency ~1                2  340        .p388.  0.145 -0.007  0.138
```

```
fit4.2 <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
              missing = "listwise", estimator = "MLM",group = "Q31b",
              group.equal=c("loadings", "intercepts", "residuals") ,
              group.partial = c( "Q12Phys_d~1", "Q12Phys_a~1",
                           "Q12Phys_f~1, "Q3Eng_n   ~1",
                            "Q3Eng_m~1","Q12Phys_f~~Q12Phys_f",
               "Q12Math_e~~Q12Math_e", "Q12Math_l~~Q12Math_l",
      "Q12Math_k~~Q12Math_k", "Q8m~~Q8m", "Q5d~~Q5d",
      "Q8f~~Q8f", "Q5f~~Q5f"))

lavTestLRT(fit3.2, fit4.2, method = "satorra.bentler2010") #not sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit3.2 2121 59311 60255 4238.3
## fit4.2 2160 59332 60115 4337.9     52.455      39    0.07347 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lavTestLRT(fit2, fit4.2, method = "satorra.bentler2010") #not sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit2   2095 59338 60390 4214.0
## fit4.2 2160 59332 60115 4337.9     78.507      65     0.1212
```

```
lavTestLRT(fit1, fit4.2, method = "satorra.bentler2010") #not sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit1   2027 59376 60707 4115.3
```

```
## fit4.2 2160 59332 60115 4337.9     159.37     133    0.05928 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


#Model 5: testing the regression paths (structural invariance)
fit5 <- sem(full_fgcs, data = study2_FYE, std.lv = TRUE, test =
"satorra.bentler",
            missing = "listwise", estimator = "MLM",group = "Q31b",
            group.equal=c("loadings", "intercepts", "residuals",
"regressions"),
            group.partial = c( "Q12Phys_d~1", "Q12Phys_a~1",  "Q12Phys_f~1",
                               "Q3Eng_m ~1", "Q3Eng_n   ~1",
                             "Q12Phys_f~~Q12Phys_f", "Q12Math_e~~Q12Math_e",
                           "Q12Math_l~~Q12Math_l", "Q12Math_k~~Q12Math_k",
                           "Q8m~~Q8m", "Q5d~~Q5d", "Q8f~~Q8f", "Q5f~~Q5f" ))


lavTestLRT(fit4.2, fit5, method ="satorra.bentler2010") #not sig
## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit4.2 2160 59332 60115 4337.9
## fit5   2160 59332 60115 4337.9          0       0


lavTestLRT(fit3.2, fit5, method ="satorra.bentler2010") #not sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##          Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit3.2 2121 59311 60255 4238.3
## fit5   2160 59332 60115 4337.9     52.455      39    0.07347 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


lavTestLRT(fit2, fit5, method ="satorra.bentler2010") #not sig

## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##        Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit2 2095 59338 60390 4214.0
## fit5 2160 59332 60115 4337.9     78.507      65     0.1212


lavTestLRT(fit1, fit5, method ="satorra.bentler2010") #not sig
```

```
## Scaled Chi Square Difference Test (method = "satorra.bentler.2010")
##
##        Df   AIC   BIC  Chisq Chisq diff Df diff Pr(>Chisq)
## fit1 2027 59376 60707 4115.3
## fit5 2160 59332 60115 4337.9     159.37     133    0.05928 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(fit5, fit.measures = T, standardized = T, modindices = F, rsq = T)
```

```
## lavaan 0.6-3 ended normally after 213 iterations
##
##   Optimization method                           NLMINB
##   Number of free parameters                        340
##   Number of equality constraints                   150
##
##                                                   Used       Total
##   Number of observations per group
##   1                                                342         455
##   0                                                114         140
##
##   Estimator                                         ML      Robust
##   Model Fit Test Statistic                    4337.883    3307.865
##   Degrees of freedom                              2160        2160
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.311
##     for the Satorra-Bentler correction
##
## Chi-square for each group:
##
##   1                                           2377.285    1812.806
##   0                                           1960.598    1495.059
##
## Model test baseline model:
##
##   Minimum Function Test Statistic            20216.072   14956.847
##   Degrees of freedom                              2162        2162
##   P-value                                        0.000       0.000
##
## User model versus baseline model:
##
##   Comparative Fit Index (CFI)                    0.879       0.910
##   Tucker-Lewis Index (TLI)                       0.879       0.910
##
##   Robust Comparative Fit Index (CFI)                         0.913
##   Robust Tucker-Lewis Index (TLI)                            0.913
##
## Loglikelihood and Information Criteria:
```

```
##
##   Loglikelihood user model (H0)            -29476.078  -29476.078
##   Loglikelihood unrestricted model (H1)    -27307.137  -27307.137
##
##   Number of free parameters                       190         190
##   Akaike (AIC)                              59332.157   59332.157
##   Bayesian (BIC)                            60115.430   60115.430
##   Sample-size adjusted Bayesian (BIC)       59512.431   59512.431
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                         0.067       0.048
##   90 Percent Confidence Interval          0.064  0.069       0.045  0.051
##   P-value RMSEA <= 0.05                         0.000       0.840
##
##   Robust RMSEA                                              0.055
##   90 Percent Confidence Interval                            0.052  0.059
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                          0.072       0.072
##
## Parameter Estimates:
##
##   Information                                Expected
##   Information saturated (h1) model         Structured
##   Standard Errors                          Robust.sem
##
##
## Group 1 [1]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f (.p1.)    0.995    0.067   14.850    0.000    1.315    0.821
##     Q3Eng_e (.p2.)    0.869    0.067   13.042    0.000    1.149    0.733
##     Q3Eng_c (.p3.)    0.901    0.067   13.537    0.000    1.191    0.711
##     Q3Eng_d (.p4.)    0.840    0.071   11.762    0.000    1.110    0.684
##   eint =~
##     Q3Eng_h (.p5.)    0.469    0.048    9.767    0.000    0.951    0.841
##     Q3Eng_j (.p6.)    0.564    0.050   11.289    0.000    1.144    0.885
##     Q3Eng_i (.p7.)    0.545    0.050   10.838    0.000    1.106    0.919
##   epc =~
##     Q3Eng_k (.p8.)    0.558    0.062    8.972    0.000    1.125    0.873
##     Q3Eng_l (.p9.)    0.546    0.061    8.980    0.000    1.102    0.817
##     Q3Eng_m (.10.)    0.571    0.062    9.247    0.000    1.151    0.808
##     Q3Eng_n (.11.)    0.516    0.058    8.824    0.000    1.040    0.821
##   prec =~
##     Q12Phy_ (.12.)    0.492    0.048   10.163    0.000    1.099    0.746
##     Q12Phy_ (.13.)    0.619    0.057   10.912    0.000    1.385    0.825
```

```
##     Q12Phy_ (.14.)    0.584    0.055   10.604    0.000    1.306    0.801
##     Q12Phy_ (.15.)    0.641    0.058   10.974    0.000    1.434    0.777
##   pint =~
##     Q12Phy_ (.16.)    0.581    0.054   10.661    0.000    1.249    0.845
##     Q12Phy_ (.17.)    0.730    0.064   11.411    0.000    1.569    0.937
##     Q12Phy_ (.18.)    0.704    0.063   11.125    0.000    1.513    0.861
##   ppc =~
##     Q12Phy_ (.19.)    0.392    0.076    5.139    0.000    1.427    0.908
##     Q12Phy_ (.20.)    0.377    0.074    5.097    0.000    1.372    0.878
##     Q12Phy_ (.21.)    0.391    0.075    5.204    0.000    1.422    0.879
##     Q12Phy_ (.22.)    0.384    0.074    5.216    0.000    1.397    0.898
##   mint =~
##     Q12Mth_ (.23.)    0.658    0.066   10.045    0.000    1.203    0.813
##     Q12Mth_ (.24.)    0.733    0.068   10.809    0.000    1.339    0.913
##     Q12Mth_ (.25.)    0.677    0.062   10.923    0.000    1.236    0.809
##   mrec =~
##     Q12Mth_ (.26.)    0.361    0.071    5.126    0.000    1.139    0.748
##     Q12Mth_ (.27.)    0.350    0.068    5.136    0.000    1.102    0.728
##     Q12Mth_ (.28.)    0.355    0.069    5.156    0.000    1.120    0.818
##     Q12Mth_ (.29.)    0.400    0.078    5.155    0.000    1.260    0.751
##   mpc =~
##     Q12Mth_ (.30.)    0.335    0.077    4.379    0.000    1.207    0.882
##     Q12Mth_ (.31.)    0.335    0.077    4.358    0.000    1.207    0.868
##     Q12Mth_ (.32.)    0.335    0.076    4.398    0.000    1.207    0.825
##     Q12Mth_ (.33.)    0.329    0.072    4.539    0.000    1.182    0.875
##   intent =~
##     Q8f     (.34.)    0.665    0.073    9.145    0.000    1.142    0.806
##     Q8e     (.35.)    0.608    0.066    9.174    0.000    1.043    0.820
##     Q8g     (.36.)    0.621    0.069    8.958    0.000    1.066    0.796
##     Q8j     (.37.)    0.656    0.071    9.243    0.000    1.126    0.812
##     Q8b     (.38.)    0.570    0.066    8.587    0.000    0.979    0.775
##   fore =~
##     Q8o     (.39.)    0.481    0.054    8.869    0.000    0.951    0.818
##     Q8n     (.40.)    0.499    0.055    9.127    0.000    0.985    0.846
##     Q8m     (.41.)    0.486    0.055    8.774    0.000    0.960    0.708
##     Q8l     (.42.)    0.482    0.053    9.110    0.000    0.952    0.812
##   engID =~
##     eint    (.43.)    1.114    0.140    7.974    0.000    0.870    0.870
##     epc     (.44.)    1.104    0.178    6.201    0.000    0.868    0.868
##     erec    (.45.)    0.545    0.069    7.904    0.000    0.654    0.654
##   physID =~
##     prec    (.46.)    1.757    0.195    9.013    0.000    0.894    0.894
##     pint    (.47.)    1.672    0.188    8.875    0.000    0.885    0.885
##     ppc     (.48.)    3.073    0.643    4.782    0.000    0.961    0.961
##   mathID =~
##     mint    (.49.)    1.403    0.173    8.090    0.000    0.837    0.837
##     mrec    (.50.)    2.742    0.584    4.695    0.000    0.948    0.948
##     mpc     (.51.)    3.171    0.771    4.113    0.000    0.961    0.961
##   engagency =~
##     Q5c     (.52.)    0.697    0.053   13.075    0.000    0.916    0.854
```

```
##     Q5d     (.53.)    0.599    0.039   15.219    0.000    0.786    0.765
##     Q5e     (.54.)    0.664    0.054   12.397    0.000    0.873    0.872
##     Q5g     (.55.)    0.702    0.056   12.437    0.000    0.922    0.870
##     Q5f     (.56.)    0.703    0.055   12.699    0.000    0.923    0.761
##   agency =~
##     fore    (.57.)    1.703    0.241    7.055    0.000    0.862    0.862
##     intent  (.58.)    1.395    0.195    7.137    0.000    0.813    0.813
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)    0.388    0.104    3.731    0.000    0.321    0.321
##     agency     (a)    0.391    0.067    5.822    0.000    0.246    0.246
##   physID ~
##     agency     (b)    0.208    0.068    3.076    0.002    0.183    0.183
##   mathID ~
##     agency     (c)    0.434    0.074    5.876    0.000    0.398    0.398
##   engagency ~
##     agency     (f)    0.672    0.110    6.086    0.000    0.512    0.512
##     mathID     (e)    0.132    0.066    2.009    0.045    0.110    0.110
##     physID     (d)    0.193    0.080    2.418    0.016    0.167    0.167
##   engID ~
##     physID     (g)    0.377    0.078    4.802    0.000    0.271    0.271
##     mathID     (h)    0.263    0.088    3.006    0.003    0.181    0.181
##   physID ~
##     mathID     (a)    0.391    0.067    5.822    0.000    0.374    0.374
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.132)    3.735    0.084   44.326    0.000    3.735    2.332
##    .Q3Eng_e (.133)    3.497    0.081   43.381    0.000    3.497    2.232
##    .Q3Eng_c (.134)    4.302    0.088   49.053    0.000    4.302    2.567
##    .Q3Eng_d (.135)    4.335    0.083   52.521    0.000    4.335    2.670
##    .Q3Eng_h (.136)    5.255    0.062   84.814    0.000    5.255    4.646
##    .Q3Eng_j (.137)    4.856    0.070   69.593    0.000    4.856    3.758
##    .Q3Eng_i (.138)    5.083    0.065   77.702    0.000    5.083    4.222
##    .Q3Eng_k (.139)    4.684    0.070   67.102    0.000    4.684    3.633
##    .Q3Eng_l (.140)    4.534    0.071   63.415    0.000    4.534    3.361
##    .Q3Eng_m           4.143    0.080   52.091    0.000    4.143    2.910
##    .Q3Eng_n           4.406    0.070   62.764    0.000    4.406    3.478
##    .Q12Phy_ (.143)    3.370    0.075   44.842    0.000    3.370    2.286
##    .Q12Phy_           3.591    0.089   40.167    0.000    3.591    2.139
##    .Q12Phy_           3.673    0.089   41.424    0.000    3.673    2.254
##    .Q12Phy_ (.146)    3.560    0.096   36.894    0.000    3.560    1.929
##    .Q12Phy_           4.751    0.082   58.115    0.000    4.751    3.214
##    .Q12Phy_ (.148)    4.422    0.090   48.943    0.000    4.422    2.640
##    .Q12Phy_ (.149)    4.046    0.094   43.204    0.000    4.046    2.302
##    .Q12Phy_ (.150)    4.150    0.084   49.131    0.000    4.150    2.643
##    .Q12Phy_ (.151)    4.040    0.084   47.893    0.000    4.040    2.586
##    .Q12Phy_ (.152)    3.871    0.087   44.368    0.000    3.871    2.393
```

```
##    .Q12Phy_ (.153)    4.217    0.083   50.927    0.000    4.217    2.710
##    .Q12Mth_ (.154)    4.631    0.081   57.459    0.000    4.631    3.128
##    .Q12Mth_ (.155)    4.472    0.081   55.376    0.000    4.472    3.048
##    .Q12Mth_ (.156)    4.362    0.080   54.569    0.000    4.362    2.856
##    .Q12Mth_ (.157)    4.348    0.079   55.075    0.000    4.348    2.855
##    .Q12Mth_ (.158)    4.555    0.077   59.025    0.000    4.555    3.012
##    .Q12Mth_ (.159)    4.507    0.073   62.169    0.000    4.507    3.294
##    .Q12Mth_ (.160)    4.336    0.088   49.545    0.000    4.336    2.586
##    .Q12Mth_ (.161)    4.512    0.073   61.811    0.000    4.512    3.299
##    .Q12Mth_ (.162)    4.444    0.075   59.387    0.000    4.444    3.198
##    .Q12Mth_ (.163)    4.335    0.077   56.416    0.000    4.335    2.965
##    .Q12Mth_ (.164)    4.580    0.071   64.208    0.000    4.580    3.389
##    .Q8f     (.165)    4.192    0.074   56.534    0.000    4.192    2.959
##    .Q8e     (.166)    4.400    0.068   65.117    0.000    4.400    3.460
##    .Q8g     (.167)    4.173    0.071   58.619    0.000    4.173    3.116
##    .Q8j     (.168)    3.954    0.073   54.092    0.000    3.954    2.851
##    .Q8b     (.169)    4.184    0.065   64.155    0.000    4.184    3.311
##    .Q8o     (.170)    4.632    0.062   74.582    0.000    4.632    3.986
##    .Q8n     (.171)    4.613    0.064   72.010    0.000    4.613    3.962
##    .Q8m     (.172)    4.446    0.068   65.546    0.000    4.446    3.279
##    .Q8l     (.173)    4.599    0.062   73.988    0.000    4.599    3.924
##    .Q5c     (.174)    5.003    0.059   84.763    0.000    5.003    4.666
##    .Q5d     (.175)    5.192    0.050  103.590    0.000    5.192    5.050
##    .Q5e     (.176)    5.083    0.054   94.669    0.000    5.083    5.078
##    .Q5g     (.177)    5.090    0.058   87.611    0.000    5.090    4.805
##    .Q5f     (.178)    5.003    0.061   82.610    0.000    5.003    4.126
##     erec              0.000                               0.000    0.000
##     eint              0.000                               0.000    0.000
##     epc               0.000                               0.000    0.000
##     prec              0.000                               0.000    0.000
##     pint              0.000                               0.000    0.000
##     ppc               0.000                               0.000    0.000
##     mint              0.000                               0.000    0.000
##     mrec              0.000                               0.000    0.000
##     mpc               0.000                               0.000    0.000
##     intent            0.000                               0.000    0.000
##     fore              0.000                               0.000    0.000
##    .engID             0.000                               0.000    0.000
##    .physID            0.000                               0.000    0.000
##    .mathID            0.000                               0.000    0.000
##    .enggncy           0.000                               0.000    0.000
##     agency            0.000                               0.000    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.69.)    0.837    0.113    7.413    0.000    0.837    0.326
##    .Q3Eng_e (.70.)    1.134    0.118    9.596    0.000    1.134    0.462
##    .Q3Eng_c (.71.)    1.390    0.148    9.395    0.000    1.390    0.495
##    .Q3Eng_d (.72.)    1.403    0.149    9.441    0.000    1.403    0.532
##    .Q3Eng_h (.73.)    0.375    0.060    6.264    0.000    0.375    0.293
```

```
##    .Q3Eng_j (.74.)    0.361    0.054    6.666    0.000    0.361    0.216
##    .Q3Eng_i (.75.)    0.226    0.056    4.035    0.000    0.226    0.156
##    .Q3Eng_k (.76.)    0.397    0.048    8.310    0.000    0.397    0.239
##    .Q3Eng_l (.77.)    0.606    0.081    7.465    0.000    0.606    0.333
##    .Q3Eng_m (.78.)    0.703    0.063   11.195    0.000    0.703    0.347
##    .Q3Eng_n (.79.)    0.524    0.074    7.124    0.000    0.524    0.327
##    .Q12Phy_ (.80.)    0.965    0.085   11.285    0.000    0.965    0.444
##    .Q12Phy_ (.81.)    0.902    0.096    9.441    0.000    0.902    0.320
##    .Q12Phy_ (.82.)    0.950    0.102    9.321    0.000    0.950    0.358
##    .Q12Phy_ (.83.)    1.352    0.133   10.164    0.000    1.352    0.397
##    .Q12Phy_           0.626    0.073    8.547    0.000    0.626    0.286
##    .Q12Phy_ (.85.)    0.345    0.055    6.297    0.000    0.345    0.123
##    .Q12Phy_ (.86.)    0.802    0.120    6.663    0.000    0.802    0.259
##    .Q12Phy_ (.87.)    0.431    0.050    8.542    0.000    0.431    0.175
##    .Q12Phy_ (.88.)    0.560    0.063    8.907    0.000    0.560    0.229
##    .Q12Phy_ (.89.)    0.594    0.061    9.684    0.000    0.594    0.227
##    .Q12Phy_ (.90.)    0.469    0.058    8.147    0.000    0.469    0.194
##    .Q12Mth_ (.91.)    0.744    0.086    8.641    0.000    0.744    0.340
##    .Q12Mth_ (.92.)    0.360    0.061    5.876    0.000    0.360    0.167
##    .Q12Mth_ (.93.)    0.805    0.098    8.227    0.000    0.805    0.345
##    .Q12Mth_ (.94.)    1.021    0.116    8.825    0.000    1.021    0.440
##    .Q12Mth_           1.074    0.148    7.241    0.000    1.074    0.469
##    .Q12Mth_ (.96.)    0.619    0.071    8.661    0.000    0.619    0.331
##    .Q12Mth_ (.97.)    1.226    0.170    7.219    0.000    1.226    0.436
##    .Q12Mth_ (.98.)    0.414    0.055    7.496    0.000    0.414    0.222
##    .Q12Mth_ (.99.)    0.475    0.054    8.827    0.000    0.475    0.246
##    .Q12Mth_           0.682    0.105    6.464    0.000    0.682    0.319
##    .Q12Mth_           0.429    0.078    5.526    0.000    0.429    0.235
##    .Q8f               0.703    0.102    6.884    0.000    0.703    0.350
##    .Q8e     (.103)    0.529    0.060    8.765    0.000    0.529    0.328
##    .Q8g     (.104)    0.657    0.067    9.770    0.000    0.657    0.367
##    .Q8j     (.105)    0.656    0.077    8.480    0.000    0.656    0.341
##    .Q8b     (.106)    0.639    0.093    6.886    0.000    0.639    0.400
##    .Q8o     (.107)    0.446    0.055    8.169    0.000    0.446    0.330
##    .Q8n     (.108)    0.384    0.061    6.267    0.000    0.384    0.284
##    .Q8m               0.918    0.136    6.752    0.000    0.918    0.499
##    .Q8l     (.110)    0.467    0.058    8.057    0.000    0.467    0.340
##    .Q5c     (.111)    0.311    0.041    7.643    0.000    0.311    0.271
##    .Q5d               0.439    0.091    4.820    0.000    0.439    0.415
##    .Q5e     (.113)    0.241    0.031    7.675    0.000    0.241    0.240
##    .Q5g     (.114)    0.273    0.047    5.803    0.000    0.273    0.243
##    .Q5f               0.618    0.139    4.450    0.000    0.618    0.420
##     erec              1.000                               0.573    0.573
##     eint              1.000                               0.243    0.243
##     epc               1.000                               0.246    0.246
##     prec              1.000                               0.200    0.200
##     pint              1.000                               0.216    0.216
##     ppc               1.000                               0.076    0.076
##     mint              1.000                               0.300    0.300
##     mrec              1.000                               0.101    0.101
```

```
##     mpc                 1.000                               0.077    0.077
##     intent              1.000                               0.339    0.339
##     fore                1.000                               0.256    0.256
##    .engID               1.000                               0.398    0.398
##    .physID              1.000                               0.772    0.772
##    .mathID              1.000                               0.842    0.842
##    .enggncy             1.000                               0.580    0.580
##     agency              1.000                               1.000    1.000
##
## R-Square:
##                      Estimate
##     Q3Eng_f             0.674
##     Q3Eng_e             0.538
##     Q3Eng_c             0.505
##     Q3Eng_d             0.468
##     Q3Eng_h             0.707
##     Q3Eng_j             0.784
##     Q3Eng_i             0.844
##     Q3Eng_k             0.761
##     Q3Eng_l             0.667
##     Q3Eng_m             0.653
##     Q3Eng_n             0.673
##     Q12Phys_c           0.556
##     Q12Phys_d           0.680
##     Q12Phys_a           0.642
##     Q12Phys_m           0.603
##     Q12Phys_f           0.714
##     Q12Phys_g           0.877
##     Q12Phys_h           0.741
##     Q12Phys_i           0.825
##     Q12Phys_j           0.771
##     Q12Phys_k           0.773
##     Q12Phys_l           0.806
##     Q12Math_f           0.660
##     Q12Math_g           0.833
##     Q12Math_h           0.655
##     Q12Math_d           0.560
##     Q12Math_e           0.531
##     Q12Math_a           0.669
##     Q12Math_m           0.564
##     Q12Math_i           0.778
##     Q12Math_j           0.754
##     Q12Math_k           0.681
##     Q12Math_l           0.765
##     Q8f                 0.650
##     Q8e                 0.672
##     Q8g                 0.633
##     Q8j                 0.659
##     Q8b                 0.600
##     Q8o                 0.670
```

```
##     Q8n                0.716
##     Q8m                0.501
##     Q8l                0.660
##     Q5c                0.729
##     Q5d                0.585
##     Q5e                0.760
##     Q5g                0.757
##     Q5f                0.580
##     erec               0.427
##     eint               0.757
##     epc                0.754
##     prec               0.800
##     pint               0.784
##     ppc                0.924
##     mint               0.700
##     mrec               0.899
##     mpc                0.923
##     intent             0.661
##     fore               0.744
##     engID              0.602
##     physID             0.228
##     mathID             0.158
##     engagency          0.420
##
##
## Group 2 [0]:
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   erec =~
##     Q3Eng_f (.p1.)    0.995    0.067   14.850    0.000    1.315    0.821
##     Q3Eng_e (.p2.)    0.869    0.067   13.042    0.000    1.149    0.733
##     Q3Eng_c (.p3.)    0.901    0.067   13.537    0.000    1.191    0.711
##     Q3Eng_d (.p4.)    0.840    0.071   11.762    0.000    1.110    0.684
##   eint =~
##     Q3Eng_h (.p5.)    0.469    0.048    9.767    0.000    0.951    0.841
##     Q3Eng_j (.p6.)    0.564    0.050   11.289    0.000    1.144    0.885
##     Q3Eng_i (.p7.)    0.545    0.050   10.838    0.000    1.106    0.919
##   epc =~
##     Q3Eng_k (.p8.)    0.558    0.062    8.972    0.000    1.125    0.873
##     Q3Eng_l (.p9.)    0.546    0.061    8.980    0.000    1.102    0.817
##     Q3Eng_m (.10.)    0.571    0.062    9.247    0.000    1.151    0.808
##     Q3Eng_n (.11.)    0.516    0.058    8.824    0.000    1.040    0.821
##   prec =~
##     Q12Phy_ (.12.)    0.492    0.048   10.163    0.000    1.099    0.746
##     Q12Phy_ (.13.)    0.619    0.057   10.912    0.000    1.385    0.825
##     Q12Phy_ (.14.)    0.584    0.055   10.604    0.000    1.306    0.801
##     Q12Phy_ (.15.)    0.641    0.058   10.974    0.000    1.434    0.777
##   pint =~
##     Q12Phy_ (.16.)    0.581    0.054   10.661    0.000    1.249    0.769
```

```
##     Q12Phy_ (.17.)    0.730    0.064   11.411    0.000    1.569    0.937
##     Q12Phy_ (.18.)    0.704    0.063   11.125    0.000    1.513    0.861
##   ppc =~
##     Q12Phy_ (.19.)    0.392    0.076    5.139    0.000    1.427    0.908
##     Q12Phy_ (.20.)    0.377    0.074    5.097    0.000    1.372    0.878
##     Q12Phy_ (.21.)    0.391    0.075    5.204    0.000    1.422    0.879
##     Q12Phy_ (.22.)    0.384    0.074    5.216    0.000    1.397    0.898
##   mint =~
##     Q12Mth_ (.23.)    0.658    0.066   10.045    0.000    1.203    0.813
##     Q12Mth_ (.24.)    0.733    0.068   10.809    0.000    1.339    0.913
##     Q12Mth_ (.25.)    0.677    0.062   10.923    0.000    1.236    0.809
##   mrec =~
##     Q12Mth_ (.26.)    0.361    0.071    5.126    0.000    1.139    0.748
##     Q12Mth_ (.27.)    0.350    0.068    5.136    0.000    1.102    0.778
##     Q12Mth_ (.28.)    0.355    0.069    5.156    0.000    1.120    0.818
##     Q12Mth_ (.29.)    0.400    0.078    5.155    0.000    1.260    0.751
##   mpc =~
##     Q12Mth_ (.30.)    0.335    0.077    4.379    0.000    1.207    0.882
##     Q12Mth_ (.31.)    0.335    0.077    4.358    0.000    1.207    0.868
##     Q12Mth_ (.32.)    0.335    0.076    4.398    0.000    1.207    0.875
##     Q12Mth_ (.33.)    0.329    0.072    4.539    0.000    1.182    0.938
##   intent =~
##     Q8f     (.34.)    0.665    0.073    9.145    0.000    1.142    0.883
##     Q8e     (.35.)    0.608    0.066    9.174    0.000    1.043    0.820
##     Q8g     (.36.)    0.621    0.069    8.958    0.000    1.066    0.796
##     Q8j     (.37.)    0.656    0.071    9.243    0.000    1.126    0.812
##     Q8b     (.38.)    0.570    0.066    8.587    0.000    0.979    0.775
##   fore =~
##     Q8o     (.39.)    0.481    0.054    8.869    0.000    0.951    0.818
##     Q8n     (.40.)    0.499    0.055    9.127    0.000    0.985    0.846
##     Q8m     (.41.)    0.486    0.055    8.774    0.000    0.960    0.835
##     Q8l     (.42.)    0.482    0.053    9.110    0.000    0.952    0.812
##   engID =~
##     eint    (.43.)    1.114    0.140    7.974    0.000    0.870    0.870
##     epc     (.44.)    1.104    0.178    6.201    0.000    0.868    0.868
##     erec    (.45.)    0.545    0.069    7.904    0.000    0.654    0.654
##   physID =~
##     prec    (.46.)    1.757    0.195    9.013    0.000    0.894    0.894
##     pint    (.47.)    1.672    0.188    8.875    0.000    0.885    0.885
##     ppc     (.48.)    3.073    0.643    4.782    0.000    0.961    0.961
##   mathID =~
##     mint    (.49.)    1.403    0.173    8.090    0.000    0.837    0.837
##     mrec    (.50.)    2.742    0.584    4.695    0.000    0.948    0.948
##     mpc     (.51.)    3.171    0.771    4.113    0.000    0.961    0.961
##   engagency =~
##     Q5c     (.52.)    0.697    0.053   13.075    0.000    0.916    0.854
##     Q5d     (.53.)    0.599    0.039   15.219    0.000    0.786    0.891
##     Q5e     (.54.)    0.664    0.054   12.397    0.000    0.873    0.872
##     Q5g     (.55.)    0.702    0.056   12.437    0.000    0.922    0.870
##     Q5f     (.56.)    0.703    0.055   12.699    0.000    0.923    0.893
```

```
##   agency =~
##     fore    (.57.)    1.703    0.241    7.055    0.000    0.862    0.862
##     intent  (.58.)    1.395    0.195    7.137    0.000    0.813    0.813
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   engID ~
##     engagency  (i)    0.388    0.104    3.731    0.000    0.321    0.321
##     agency     (a)    0.391    0.067    5.822    0.000    0.246    0.246
##   physID ~
##     agency     (b)    0.208    0.068    3.076    0.002    0.183    0.183
##   mathID ~
##     agency     (c)    0.434    0.074    5.876    0.000    0.398    0.398
##   engagency ~
##     agency     (f)    0.672    0.110    6.086    0.000    0.512    0.512
##     mathID     (e)    0.132    0.066    2.009    0.045    0.110    0.110
##     physID     (d)    0.193    0.080    2.418    0.016    0.167    0.167
##   engID ~
##     physID     (g)    0.377    0.078    4.802    0.000    0.271    0.271
##     mathID     (h)    0.263    0.088    3.006    0.003    0.181    0.181
##   physID ~
##     mathID     (a)    0.391    0.067    5.822    0.000    0.374    0.374
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.132)    3.735    0.084   44.326    0.000    3.735    2.332
##    .Q3Eng_e (.133)    3.497    0.081   43.381    0.000    3.497    2.232
##    .Q3Eng_c (.134)    4.302    0.088   49.053    0.000    4.302    2.567
##    .Q3Eng_d (.135)    4.335    0.083   52.521    0.000    4.335    2.670
##    .Q3Eng_h (.136)    5.255    0.062   84.814    0.000    5.255    4.646
##    .Q3Eng_j (.137)    4.856    0.070   69.593    0.000    4.856    3.758
##    .Q3Eng_i (.138)    5.083    0.065   77.702    0.000    5.083    4.222
##    .Q3Eng_k (.139)    4.684    0.070   67.102    0.000    4.684    3.633
##    .Q3Eng_l (.140)    4.534    0.071   63.415    0.000    4.534    3.361
##    .Q3Eng_m           4.401    0.127   34.648    0.000    4.401    3.091
##    .Q3Eng_n           4.628    0.105   44.161    0.000    4.628    3.652
##    .Q12Phy_ (.143)    3.370    0.075   44.842    0.000    3.370    2.286
##    .Q12Phy_           3.726    0.135   27.681    0.000    3.726    2.219
##    .Q12Phy_           3.402    0.145   23.390    0.000    3.402    2.088
##    .Q12Phy_ (.146)    3.560    0.096   36.894    0.000    3.560    1.929
##    .Q12Phy_           5.032    0.126   40.051    0.000    5.032    3.098
##    .Q12Phy_ (.148)    4.422    0.090   48.943    0.000    4.422    2.640
##    .Q12Phy_ (.149)    4.046    0.094   43.204    0.000    4.046    2.302
##    .Q12Phy_ (.150)    4.150    0.084   49.131    0.000    4.150    2.643
##    .Q12Phy_ (.151)    4.040    0.084   47.893    0.000    4.040    2.586
##    .Q12Phy_ (.152)    3.871    0.087   44.368    0.000    3.871    2.393
##    .Q12Phy_ (.153)    4.217    0.083   50.927    0.000    4.217    2.710
##    .Q12Mth_ (.154)    4.631    0.081   57.459    0.000    4.631    3.128
##    .Q12Mth_ (.155)    4.472    0.081   55.376    0.000    4.472    3.048
##    .Q12Mth_ (.156)    4.362    0.080   54.569    0.000    4.362    2.856
```

```
##    .Q12Mth_ (.157)    4.348    0.079   55.075    0.000    4.348    2.855
##    .Q12Mth_ (.158)    4.555    0.077   59.025    0.000    4.555    3.216
##    .Q12Mth_ (.159)    4.507    0.073   62.169    0.000    4.507    3.294
##    .Q12Mth_ (.160)    4.336    0.088   49.545    0.000    4.336    2.586
##    .Q12Mth_ (.161)    4.512    0.073   61.811    0.000    4.512    3.299
##    .Q12Mth_ (.162)    4.444    0.075   59.387    0.000    4.444    3.198
##    .Q12Mth_ (.163)    4.335    0.077   56.416    0.000    4.335    3.143
##    .Q12Mth_ (.164)    4.580    0.071   64.208    0.000    4.580    3.636
##    .Q8f     (.165)    4.192    0.074   56.534    0.000    4.192    3.242
##    .Q8e     (.166)    4.400    0.068   65.117    0.000    4.400    3.460
##    .Q8g     (.167)    4.173    0.071   58.619    0.000    4.173    3.116
##    .Q8j     (.168)    3.954    0.073   54.092    0.000    3.954    2.851
##    .Q8b     (.169)    4.184    0.065   64.155    0.000    4.184    3.311
##    .Q8o     (.170)    4.632    0.062   74.582    0.000    4.632    3.986
##    .Q8n     (.171)    4.613    0.064   72.010    0.000    4.613    3.962
##    .Q8m     (.172)    4.446    0.068   65.546    0.000    4.446    3.870
##    .Q8l     (.173)    4.599    0.062   73.988    0.000    4.599    3.924
##    .Q5c     (.174)    5.003    0.059   84.763    0.000    5.003    4.666
##    .Q5d     (.175)    5.192    0.050  103.590    0.000    5.192    5.885
##    .Q5e     (.176)    5.083    0.054   94.669    0.000    5.083    5.078
##    .Q5g     (.177)    5.090    0.058   87.611    0.000    5.090    4.805
##    .Q5f     (.178)    5.003    0.061   82.610    0.000    5.003    4.841
##     erec              0.056    0.115    0.484    0.628    0.042    0.042
##     eint              0.115    0.110    1.046    0.296    0.056    0.056
##     epc              -0.458    0.127   -3.608    0.000   -0.227   -0.227
##     prec              0.040    0.156    0.256    0.798    0.018    0.018
##     pint             -0.137    0.132   -1.039    0.299   -0.064   -0.064
##     ppc              -0.152    0.097   -1.567    0.117   -0.042   -0.042
##     mint              0.286    0.123    2.336    0.019    0.157    0.157
##     mrec              0.158    0.140    1.129    0.259    0.050    0.050
##     mpc              -0.137    0.117   -1.173    0.241   -0.038   -0.038
##     intent            0.200    0.101    1.989    0.047    0.117    0.117
##     fore              0.084    0.089    0.944    0.345    0.043    0.043
##    .engID            -0.225    0.107   -2.106    0.035   -0.142   -0.142
##    .physID           -0.269    0.109   -2.471    0.013   -0.236   -0.236
##    .mathID            0.165    0.105    1.582    0.114    0.152    0.152
##    .enggncy           0.224    0.115    1.949    0.051    0.171    0.171
##     agency            0.143    0.100    1.433    0.152    0.143    0.143
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .Q3Eng_f (.69.)    0.837    0.113    7.413    0.000    0.837    0.326
##    .Q3Eng_e (.70.)    1.134    0.118    9.596    0.000    1.134    0.462
##    .Q3Eng_c (.71.)    1.390    0.148    9.395    0.000    1.390    0.495
##    .Q3Eng_d (.72.)    1.403    0.149    9.441    0.000    1.403    0.532
##    .Q3Eng_h (.73.)    0.375    0.060    6.264    0.000    0.375    0.293
##    .Q3Eng_j (.74.)    0.361    0.054    6.666    0.000    0.361    0.216
##    .Q3Eng_i (.75.)    0.226    0.056    4.035    0.000    0.226    0.156
##    .Q3Eng_k (.76.)    0.397    0.048    8.310    0.000    0.397    0.239
##    .Q3Eng_l (.77.)    0.606    0.081    7.465    0.000    0.606    0.333
```

```
##    .Q3Eng_m (.78.)    0.703    0.063   11.195    0.000    0.703    0.347
##    .Q3Eng_n (.79.)    0.524    0.074    7.124    0.000    0.524    0.327
##    .Q12Phy_ (.80.)    0.965    0.085   11.285    0.000    0.965    0.444
##    .Q12Phy_ (.81.)    0.902    0.096    9.441    0.000    0.902    0.320
##    .Q12Phy_ (.82.)    0.950    0.102    9.321    0.000    0.950    0.358
##    .Q12Phy_ (.83.)    1.352    0.133   10.164    0.000    1.352    0.397
##    .Q12Phy_           1.078    0.233    4.637    0.000    1.078    0.409
##    .Q12Phy_ (.85.)    0.345    0.055    6.297    0.000    0.345    0.123
##    .Q12Phy_ (.86.)    0.802    0.120    6.663    0.000    0.802    0.259
##    .Q12Phy_ (.87.)    0.431    0.050    8.542    0.000    0.431    0.175
##    .Q12Phy_ (.88.)    0.560    0.063    8.907    0.000    0.560    0.229
##    .Q12Phy_ (.89.)    0.594    0.061    9.684    0.000    0.594    0.227
##    .Q12Phy_ (.90.)    0.469    0.058    8.147    0.000    0.469    0.194
##    .Q12Mth_ (.91.)    0.744    0.086    8.641    0.000    0.744    0.340
##    .Q12Mth_ (.92.)    0.360    0.061    5.876    0.000    0.360    0.167
##    .Q12Mth_ (.93.)    0.805    0.098    8.227    0.000    0.805    0.345
##    .Q12Mth_ (.94.)    1.021    0.116    8.825    0.000    1.021    0.440
##    .Q12Mth_           0.793    0.190    4.174    0.000    0.793    0.395
##    .Q12Mth_ (.96.)    0.619    0.071    8.661    0.000    0.619    0.331
##    .Q12Mth_ (.97.)    1.226    0.170    7.219    0.000    1.226    0.436
##    .Q12Mth_ (.98.)    0.414    0.055    7.496    0.000    0.414    0.222
##    .Q12Mth_ (.99.)    0.475    0.054    8.827    0.000    0.475    0.246
##    .Q12Mth_           0.447    0.098    4.568    0.000    0.447    0.235
##    .Q12Mth_           0.189    0.046    4.088    0.000    0.189    0.119
##    .Q8f               0.368    0.076    4.852    0.000    0.368    0.220
##    .Q8e     (.103)    0.529    0.060    8.765    0.000    0.529    0.328
##    .Q8g     (.104)    0.657    0.067    9.770    0.000    0.657    0.367
##    .Q8j     (.105)    0.656    0.077    8.480    0.000    0.656    0.341
##    .Q8b     (.106)    0.639    0.093    6.886    0.000    0.639    0.400
##    .Q8o     (.107)    0.446    0.055    8.169    0.000    0.446    0.330
##    .Q8n     (.108)    0.384    0.061    6.267    0.000    0.384    0.284
##    .Q8m               0.399    0.088    4.512    0.000    0.399    0.302
##    .Q8l     (.110)    0.467    0.058    8.057    0.000    0.467    0.340
##    .Q5c     (.111)    0.311    0.041    7.643    0.000    0.311    0.271
##    .Q5d               0.160    0.034    4.736    0.000    0.160    0.206
##    .Q5e     (.113)    0.241    0.031    7.675    0.000    0.241    0.240
##    .Q5g     (.114)    0.273    0.047    5.803    0.000    0.273    0.243
##    .Q5f               0.216    0.062    3.464    0.001    0.216    0.202
##     erec              1.000                               0.573    0.573
##     eint              1.000                               0.243    0.243
##     epc               1.000                               0.246    0.246
##     prec              1.000                               0.200    0.200
##     pint              1.000                               0.216    0.216
##     ppc               1.000                               0.076    0.076
##     mint              1.000                               0.300    0.300
##     mrec              1.000                               0.101    0.101
##     mpc               1.000                               0.077    0.077
##     intent            1.000                               0.339    0.339
##     fore              1.000                               0.256    0.256
##    .engID             1.000                               0.398    0.398
```

```
##    .physID             1.000                                  0.772    0.772
##    .mathID             1.000                                  0.842    0.842
##    .enggncy            1.000                                  0.580    0.580
##     agency             1.000                                  1.000    1.000
##
## R-Square:
##                     Estimate
##     Q3Eng_f            0.674
##     Q3Eng_e            0.538
##     Q3Eng_c            0.505
##     Q3Eng_d            0.468
##     Q3Eng_h            0.707
##     Q3Eng_j            0.784
##     Q3Eng_i            0.844
##     Q3Eng_k            0.761
##     Q3Eng_l            0.667
##     Q3Eng_m            0.653
##     Q3Eng_n            0.673
##     Q12Phys_c          0.556
##     Q12Phys_d          0.680
##     Q12Phys_a          0.642
##     Q12Phys_m          0.603
##     Q12Phys_f          0.591
##     Q12Phys_g          0.877
##     Q12Phys_h          0.741
##     Q12Phys_i          0.825
##     Q12Phys_j          0.771
##     Q12Phys_k          0.773
##     Q12Phys_l          0.806
##     Q12Math_f          0.660
##     Q12Math_g          0.833
##     Q12Math_h          0.655
##     Q12Math_d          0.560
##     Q12Math_e          0.605
##     Q12Math_a          0.669
##     Q12Math_m          0.564
##     Q12Math_i          0.778
##     Q12Math_j          0.754
##     Q12Math_k          0.765
##     Q12Math_l          0.881
##     Q8f                0.780
##     Q8e                0.672
##     Q8g                0.633
##     Q8j                0.659
##     Q8b                0.600
##     Q8o                0.670
##     Q8n                0.716
##     Q8m                0.698
##     Q8l                0.660
##     Q5c                0.729
```

```
##     Q5d                 0.794
##     Q5e                 0.760
##     Q5g                 0.757
##     Q5f                 0.798
##     erec                0.427
##     eint                0.757
##     epc                 0.754
##     prec                0.800
##     pint                0.784
##     ppc                 0.924
##     mint                0.700
##     mrec                0.899
##     mpc                 0.923
##     intent              0.661
##     fore                0.744
##     engID               0.602
##     physID              0.228
##     mathID              0.158
##     engagency           0.420
##
## Defined Parameters:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     ind1              0.064    0.017    3.685    0.000    0.027    0.027
##     ind3              0.114    0.040    2.872    0.004    0.072    0.072
##     ind4              0.078    0.029    2.715    0.007    0.049    0.049
##     total             0.778    0.096    8.078    0.000    0.568    0.568
```

```
fitmeasures(fit5)
```

```
##                          npar                          fmin
##                       190.000                         4.756
##                         chisq                            df
##                      4337.883                      2160.000
##                        pvalue                  chisq.scaled
##                         0.000                      3307.865
##                     df.scaled                 pvalue.scaled
##                      2160.000                         0.000
##          chisq.scaling.factor                baseline.chisq
##                         1.311                     20216.072
##                   baseline.df               baseline.pvalue
##                      2162.000                         0.000
##         baseline.chisq.scaled            baseline.df.scaled
##                     14956.847                      2162.000
##        baseline.pvalue.scaled baseline.chisq.scaling.factor
##                         0.000                         1.352
##                           cfi                           tli
##                         0.879                         0.879
##                          nnfi                           rfi
##                         0.879                         0.785
##                           nfi                          pnfi
```

```
##                          0.785                          0.785
##                            ifi                            rni
##                          0.879                          0.879
##                     cfi.scaled                     tli.scaled
##                          0.910                          0.910
##                     cfi.robust                     tli.robust
##                          0.913                          0.913
##                    nnfi.scaled                    nnfi.robust
##                          0.910                          0.913
##                     rfi.scaled                     nfi.scaled
##                          0.779                          0.779
##                     ifi.scaled                     rni.scaled
##                          0.910                          0.910
##                     rni.robust                           logl
##                          0.913                     -29476.078
##              unrestricted.logl                            aic
##                     -27307.137                      59332.157
##                            bic                         ntotal
##                      60115.430                        456.000
##                           bic2                          rmsea
##                      59512.431                          0.067
##                 rmsea.ci.lower                 rmsea.ci.upper
##                          0.064                          0.069
##                   rmsea.pvalue                   rmsea.scaled
##                          0.000                          0.048
##          rmsea.ci.lower.scaled          rmsea.ci.upper.scaled
##                          0.045                          0.051
##            rmsea.pvalue.scaled                   rmsea.robust
##                          0.840                          0.055
##          rmsea.ci.lower.robust          rmsea.ci.upper.robust
##                          0.052                          0.059
##            rmsea.pvalue.robust                            rmr
##                             NA                          0.140
##                     rmr_nomean                           srmr
##                          0.143                          0.072
##                   srmr_bentler            srmr_bentler_nomean
##                          0.072                          0.073
##                           crmr                    crmr_nomean
##                          0.073                          0.067
##                     srmr_mplus              srmr_mplus_nomean
##                          0.074                          0.068
##                          cn_05                          cn_01
##                        239.543                        244.442
##                            gfi                           agfi
##                          0.892                          0.883
##                           pgfi                            mfi
##                          0.820                          0.092
```

```
#Q24. For any AP exams you took, please indicate your test score

table(study2_FYE$Q24a, useNA = 'always') #Calculus AB

##
##    0    1    2    3    4    5 <NA>
##  365   26   44   60   54   46    0

#0    1    2    3    4    5 <NA>
#365   26   44   60   54   46    0

table(study2_FYE$Q24b, useNA = 'always') # Calculus BC

##
##    0    1    2    3    4    5 <NA>
##  521    4   14   17   18   21    0

#0      1    2    3    4    5 <NA>
#521    4   14   17   18   21    0


table(study2_FYE$Q24f, useNA = 'always') #Physics B

##
##    0    1    2    3    4    5 <NA>
##  525   10   20   26   11    3    0

#0     1    2    3    4    5 <NA>
#525   10   20   26   11    3    0

table(study2_FYE$Q24g, useNA = 'always') #Physics C

##
##    0    1    2    3    4    5 <NA>
##  537    2   15   12   12   17    0

#0      1    2    3    4    5 <NA>
#537    2   15   12   12   17    0

table(study2_FYE$Q24h, useNA = 'always') #environmental science

##
##    0    1    2    3    4    5 <NA>
##  562    2   10    9   11    1    0

#0    1    2    3    4    5 <NA>
#562    2   10    9   11    1    0

table(study2_FYE$Q24d, useNA = 'always') #biology
```

```
##
##    0    1    2    3    4    5 <NA>
##  530    3   13   26   20    3    0

# 0    1    2    3    4    5 <NA>
# 530    3   13   26   20    3    0

table(study2_FYE$Q24i, useNA = 'always')

##
##    0    1    2    3    4    5 <NA>
##  554    6    8   14    7    6    0

#0    1    2    3    4    5 <NA>
#554    6    8   14    7    6    0


table(study2_FYE$Q24e, useNA = 'always')

##
##    0    1    2    3    4    5 <NA>
##  517    9   26   29    8    6    0

 #0    1    2    3    4    5 <NA>
# 517    9   26   29    8    6    0

table(study2_FYE$Q24c, useNA = 'always')

##
##    0    1    2    3    4    5 <NA>
##  535    8   10   16   19    7    0

#   0    1    2    3    4    5 <NA>
# 535    8   10   16   19    7    0
```

APPENDIX G. PARTICIPANT RECRUITMENT EMAIL

My name is Dina Verdin, I am a Ph.D. student in engineering education at Purdue University.

I am inviting a select few women in engineering from [name of participants' institution] to participate in my study.

My study focuses on your experiences as underrepresented students in engineering, with the goal of understanding how you come to see yourself as an engineer (develop an engineering identity).

As a Latina myself, I think it is important to learn about how our undergraduate trajectory helps us or possibly hinders our goal of becoming engineers. I hope to get this insight through a **one-hour interview**.

I hope you will consider participating in my study. Participants will be given a $20 Amazon Gift card.

Please email me at dverdin@purdue.edu if you would like to participate in this study.

Thank you,
Dina

APPENDIX H. INTERVIEW PROTOCOL

Interview 1 Protocol

I. Introduction

Hello {Insert Student Name},

I am, {Insert My Name}, a student at Purdue University. Thank you for agreeing to participate in my dissertation study.

II. Inform Student about Consent (Do NOT record before the form is signed)

Before starting the interview, it is important that you sign the form that states that you give us consent to audio record this conversation. We will protect your anonymity by referring to your story with a pseudonym or fake name, as well as securing the recording on a password protected server. If at any time you decide to withdraw from the study, please let me know.

You will receive a $20 Amazon gift card for participating in this study.

*Give participant time to review consent form and ask any questions that they may have. Counter sign the consent form once they have signed it.

III. Purpose of the study

The purpose of this interview is to understand your background, pathway to engineering, and early engineer experiences. We are interested in understanding how early career engineering students navigate their pathways in engineering to better understand how students develop their identities as engineers. This session should take approximately 60-90 minutes.

IV. Notes to Interviewee

There are no right or wrong answers here,

The information you provide us today will not be linked to your real name. We use pseudonyms (fake names) to protect your confidentiality. What would you like your pseudonym to be?

--------------------------*Pause and wait for the student to give you a name*-------------------------

I hope that you have the freedom and comfort to speak freely, I am not here to make judgements or criticize any comments you make.

Some questions may seem repetitive but I want to make sure that I are getting the full depth of the story.

Feel free to take your time and reflect on the questions before answering.

In general, we are interested in your engineering story.

A. Background

- **a.** Can you tell me about how you came to be where you are now.
- **b.** If the student needs more help in starting to tell their story:
    - **i.** Can you give me a quick overview of your story (who you are, how you grew up, how you got to be here).
- **c.** Narrative prompts for pauses ***DO NOT INTERRUPT***:
    - **i.** Then what happened?
    - **ii.** How does that lead to where you are now?
    - **iii.** Can you tell me a little bit more about [*some topic they discussed*]?

--Transition to the next story--------------------------------------

B. Pathway to Engineering

- **a.** Tell me about your pathway into engineering.
- **b.** What about how you got into your major?
- **c.** Narrative prompts for pauses ***DO NOT INTERRUPT***:
    - **i.** Then what happened?
    - **ii.** How does that lead to where you are now?
    - **iii.** Can you tell me a little bit more about [*some topic they discussed*]?

--Transition to the next story--------------------------------------

C. 1st Year Engineering Experience

- **a.** Tell me about your experience as a first-year engineering student.
- **b.** Narrative prompts for pauses ***DO NOT INTERRUPT***:
    - **i.** Then what happened?
    - **ii.** How does that lead to where you are now?
    - **iii.** Can you tell me a little bit more about [*some topic they discussed*]?

D. Wrap Up

- **a.** Is there anything else that you'd like to share with me?
- **b.** Thank you for taking the time to share your story today. We will follow up with you for another interview next semester.

Interview 2 Protocol

I. Introduction

Hello {Insert Student Name},

Thank you again for doing a follow up interview.

- **a.** Tell me about your experience has been this past semester/quarter.
- **b.** Tell me about your classroom experiences this year
- **c.** Tell me about your interactions with faculty and staff in the college of engineering.
- **d.** Tell me about your interactions with your peers in engineering.

--Transition to follow up questions----------------------------

II. Follow up

- **a.** Generate a list of follow up questions from Interview 1 transcripts

III. Wrap Up

- a. Are there additional experiences that you felt were important to your development that we had not discussed here?
- b. Is there anything else that you'd like to share with me?
- c. Thank you for taking the time to share your story today. We will follow up with you for another interview in the fall.

<u>Interview 3 Protocol</u>

I. Introduction

Hello {Insert Student Name},

Thank you again for doing a follow up interview.

Notes to Interviewee

There are no right or wrong answers here.

Feel free to take your time and reflect on the questions before answering.

In general, we are interested in your engineering story.

II. Journey Mapping Activity

Prior to the interview, we asked you to complete a journey plot. We asked you to indicate your highs and lows (e.g., positive and negative experiences) during your experience as an engineering student from when you started to now. We want to understand your experiences in and out of the classroom that were positive as well as difficult for you in engineering.

A. Tell me about the journey map you drew?
**Refer to a high or low point to elicit more information about the experience. **

a. Then what happened?
b. How does that lead to where you are now?
c. Can you tell me a little bit more about [*some topic they discussed*]?

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