CHARACTERIZING TEAM ORIENTATION, LEADERSHIP AND COORDINATION STRATEGIES USED BY SYSTEM ANALYSIS AND DESIGN TEAMS

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Item	Definition
Agile Software methodology	Agile software development refers to a group of software development methodologies based on iterative development, where requirements and solutions evolve through collaboration between self-organizing **cross**-functional teams.
Functional Prototype	Sample or model of a product built to test a concept or process or to act as a visual prop to be replicated, improved and learned from.
Software Development Life Cycle	Term used in systems engineering, information systems and software engineering to describe a process for planning, creating, testing, and deploying an information system.
Scrum	Agile framework for managing knowledge work, with an emphasis on software development

LIST OF ABBREVIATIONS

AAW:	Anti-air Warfare
ABET:	Accreditation Board for Engineering and Technology
CNIT:	Computer and Information Technology
RQ:	Research Question
SDLC:	Software Development Life Cycle
TWQ:	Teamwork Quality

ABSTRACT

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There is an increasing need to design and implement technological solutions to span scientific advances, facilitate people's life and increase the efficiency of daily tasks. This brings into the picture professionals with sufficient technical skills to bring to life these technological solutions. Considering the outreach and size of said solutions, technical knowledge is not enough to succeed, but soft skills such as communication and teamwork. Engineering and technology professionals need to function effectively in teams to accomplish a common goal. Therefore, this study characterizes the strategies that teams use in order to accomplish their goals through successful team interactions. In addition, this study explores how these strategies vary during a semester-long project and how these variations may affect team interactions and different performance indicators.

CHAPTER 1. INTRODUCTION

The purpose of this study is to identify different characteristics of teamwork organization and performance as experienced by learners working in software development teams. The ultimate goal is to provide a better understanding of teamwork characteristics through a comprehensive framework. Such findings can be adapted into a pedagogy that promotes teamwork while following a software development methodology, in this case, Scrum; and measure these skills in a way that they could act as indicators of successful projects. The following sections of this chapter explain in detail the purpose and significance of this study.

1.1 Background

Professionals in engineering, computing, and technology are now required to possess not only the technical knowledge of their respective disciplines but also the soft skills such as communication and teamwork (Bailey & Stefaniak, 1999). Such a combination of skills, both technical and soft skills, have been identified as equally relevant by academia and industry professionals (Aasheim, Li, & Williams, 2009). As such, bodies of program accreditation such as ABET (2016) have, for instance, identified "an ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs" as equally important as "an ability to function effectively on teams to accomplish a common goal." Accordingly, engineering, computing and technology educators need to identify ways in which students can effectively develop technical and interpersonal skills throughout their undergraduate programs of study.

Teams are defined as "a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable" (Katzenbach & Smith, 1993, p. 112). Specifically focusing on teamwork, since software development is primarily a team effort (Faraj & Spoull, 2000, as cited in Weimar et al., 2014), it is important to understand the factors or characteristics of teamwork that play an important role in the context of software development. Few empirical studies have investigated teamwork characteristics. For instance, in 2001 a study offering a comprehensive overview of teamwork in innovative projects (Hoegl & Gemuenden, 2001) defined six facets that were

encompassed in a concept called Teamwork Quality (TWQ). Nonetheless, this study had a great focus on the relationship between the development teams and the organizations, associating performance to work-related satisfaction. Currently, there is still a need to determine what makes software projects succeed and software teams efficient. According to The Chaos Report, at least 71% of software projects end up in failure or challenged (The Standish Group, 2015), a warning for the ongoing need for better team practices.

1.2 Significance of the study

In educational contexts, team effectiveness depends on multiple factors such as team formation, team members' abilities and characteristics, role assignment within a team, decision-making strategies of teams, team leadership, and interdependency. (Fransen, Kirschner, & Erkens, 2011). It also depends on task characteristics and shared understanding. Without a shared understanding, the individual members may be headed toward different goals, which in turn may lead to ineffective/lack of feedback or assistance (Salas, Sims, & Shawn Burke, 2005). Therefore, there is a need to find the right strategies that allow these groups to succeed, not only in terms of pedagogies (e.g., cooperative learning, problem-based learning, flipped-classroom, etc.), but also in terms of promoting teamwork skills that can ensure effective individual and team performance (Moe et al., 2010).

To aid the strategies that promote a more organic approach to teamwork, the incorporation of Agile Software methodologies that focus on self-managing teams is key. This approach helps teams to enact shared leadership which not only helps with role assignment, but it also promotes the shift in decision-making strategies and the shared understanding of the common goal.

Promoting the aforementioned strategies in the current educational context helps to align learners with the current reality of the software industry on which the use of Agile methodologies is predominant due to a higher success rate than traditional methodologies (The Standish Group, 2015) and the increasing trend in distributed teams (Carver, Muccini, & Yamashita, 2017), making the development of the previously mentioned teamwork characteristics much more relevant.

1.3 Statement of Purpose

It is a difficult task to fit into a course everything that entails the software development life cycle, prototyping, teamwork and leadership, and guarantee the achievement of high cognitive outcomes in these areas. Hence, it is critical to fit together the right pieces in terms of pedagogy, instructional design, team formation, and class dynamics. These conditions can allow students to develop a higher ability to design, implement and evaluate a computer-based system.

The aim of this study is to identify teamwork characteristics in terms of their perceived organizational skills and performance that fit into the alignment previously mentioned. Once these characteristics are identified, additional analysis will be performed to identify patterns in students' perceived interactions and performance throughout two complete full semesters.

Efforts in tailoring tasks in a way that they elicit teamwork characteristics in students while focusing on the analysis, design, and implementation, have already been studied (Magana, Seah, & Thomas, 2018) yielding positive results. Now, the need is (a) to determine what team characteristics that enact effective team performance are, and (b) to explore how the presence or enacting of these skills actually affect teams throughout a semester-long course.

1.4 Research Questions

In order to provide a concrete path to follow with this study, the research questions that will guide it are:

RQ1: What are the characteristics of students' self-reported teamwork experiences as part of a semester-long project?

RQ2: How do these self-reported teamwork characteristics change over time throughout a semester-long project?

RQ3: Which of these self-reported teamwork characteristics were the most impactful on overall team performance during a semester-long project?

1.5 Scope of the Study

Scrum is one of the most prevalent Agile Software methodologies that are used in the software industry (The Standish Group, 2015). Therefore, it is important to introduce these approaches into educational settings, and at the same time measure their effectiveness in team performance and team organization.

One of the critical activities included in the Scrum framework is the sprint retrospective. This specific activity allows a team to inspect themselves and determine which aspects of teamwork could be modified in order to improve productivity for the upcoming software iteration (Schwaber & Sutherland, 2017).

This study focuses on analyzing the sprint retrospectives to characterize how teams reflect on their team skills as they carried out the analysis and design of systems as part of a Computer and Information Technology course. As part of this course, students worked with a case study, and enacted Scrum with five iterations, providing multiple snapshots during a semester-long project to gather information regarding team characteristics. In addition, these multiple college-level teams submitted system definition and design documents to support their work, which helped to account for success measures among the teams.

1.6 Assumptions

The following assumptions were inherent to the design of this study:

- Students have certain level of experience in systems analysis and design components, enough to allow for the successful completion of a semester-long project.
- The team retrospectives are an accurate representation of the state of the teams at the moment they undergo this process.
- The team retrospective is carried out by all the members of the team
- The semester-long project is close enough to a real-life scenario that it can effectively represent industry-like scenarios and team interactions.

1.7 Limitations

The following limitations were inherent to the design of this study:

- This study relies in the information provided by the students and no observations were conducted to further analyze team interactions.
- This study won´t redo the efforts to analyze the instructional methodologies used to teach system analysis and design methods.
- This study uses performance measures (See Appendix B) to determine the quality of the project delivered by the students. Nonetheless, it is not measuring the level of performance achieved by the students regarding system analysis and design methods.
- This study is only looking for team characteristics, no other indicator within the teams will be measured.

1.8 Delimitations

The following delimitations were inherent to the design of this study:

- This study will not asses the quality of the final prototypes delivered by the students. Only the quality of the technical documentation submitted.
- The instructional approach used for the students in this study will be presented in following chapters, but no in-depth discussion will be held.

CHAPTER 2. LITERATURE REVIEW

This study focuses on software development teams. Teams are defined as "a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable" (Katzenbach & Smith, 1993). Since software development is primarily a team effort (Faraj & Spoull, 2000, as cited in Weimar et al., 2014), it is important to understand the factors or characteristics of teamwork that play an important role in software.

Vast research has been conducted in the way teams operate and perform (Guzzo & Dickson, 1996; Marks, Mathieu, & Zaccaro, 2001; Moe, Dingsøyr, & Dybå, 2010; Salas, Stagl, & Burke, 2005; Salas, Stagl, Burke, & Goodwin, 2007). As a result, several dimensions of teamwork have been analyzed and studied. However, there is no consensus on a common conceptual framework for teamwork (Burke et al., 2006; Hoegl and Gemuenden, 2001; Langfred, 2000; Marks, Mathieu, et al., 2001; Salas, Sims, et al., 2005; as cited in Moe et al., 2010).

Guzzo & Dickinson (1996) acknowledged the existence of definitional struggles in the area of teamwork. They offered a definition that accommodates this conceptual struggle as groups per se are individuals who see themselves as part of a social entity and have some degree of interdependence. Furthermore, they analyzed teams under the scope of cohesiveness, group composition, and leadership and performance. They looked at group composition and the medium defining the groups (i.e. Flight crews, computer-assisted groups, problem-solving groups, etc.). The identified aspects were centered in diversity, familiarity, team boundaries, and how the different combination of this aspects in specific mediums enhances or hurts team effectiveness (Guzzo & Dickson, 1996).

Marks, Mathieu & Zaccaro (2001) focused their work on defining teams based on team processes rather than team characteristics. They defined team process in the context of a multiphase episodic framework related to goal accomplishment, arguing that teams are "multitasking units that perform multiple process simultaneously and sequentially to orchestrate goal-directed taskwork" (Marks et al., 2001, p. 356). The center of this study was to provide a taxonomy that reflected their time-base

conceptual framework. The goal of this framework was to put in context the role of processes in team effectiveness. Nonetheless, they are clear in their approach and how "there is still no conceptual framework on team processes, no agreed-upon definition or set of process dimensions and challenges associated with its measurement." (Marks et al., 2001, p. 356).

Salas, Sims & Burke (2005) highlighted that teamwork has been studied and fragmented through the years, causing the findings not to be useful in practice. They proposed a way to "boil down" what researchers know about teamwork and presented the "Big Five" in teamwork as the essential components. They conducted a broad study of literature and defined team leadership, mutual performance monitoring, backup behavior, adaptability, and team orientation as the key characteristics in teams. These core components of teamwork require coordinating mechanism of shared mental models, closed-loop communication and mutual trust, in order to be put in place during team tasks (Salas, Sims, & Shawn Burke, 2005). Although the aim of the study was to bridge the gap between academicians and practitioners of teamwork by providing a conceptual framework, "additional variables that have also been found to affect team performance and team effectiveness should not be disregarded" (Salas, Sims, et al., 2005, p. 592).

More recently, the work of Salas, Stagl & Burke (2005), points out the need for explicit needs on teamwork research. The seven specific needs highlighted are: Conduct team research "in the wild", the need to understand distributed work, a need for a functional outlook on team leadership, the need to focus on team culture, master change with adaptive teams, better integrate models and frameworks of team effectiveness, and the need to leverage research from all quarters (i.e. teamwork in different disciplines) (Salas, Stagl, et al., 2005). It also points out to how future work should consider these needs given the changing nature of teams (Salas, Stagl, et al., 2005).

Therefore, the purpose of this literature review is to highlight a set of different but interrelated themes on team effectiveness, while addressing some of the needs in team knowledge. These themes included: team characteristics, team performance, cooperation, and how these themes interrelate in educational and industry settings.

From the work analyzed by Salas et al. (2007) and additional literature considering teamwork skills or interactions (Dillenbourg, 2007; Fransen, Kirschner, & Erkens, 2011; Gokhale, 1995; Hamilton, Mancuso, Mohammed, Tesler, & McNeese, 2017; Salas, Sims, et al., 2005; Salas, Stagl, et al., 2005), the common factor among all of them relates to collaborative learning. Collaborative learning refers to "an instruction method in which students at various performance levels work together in small groups toward a common goal. The students are responsible for one another's learning as well as their own. Thus, the success of one student helps other students to be successful." (Gokhale, 1995, p.22). This definition helped narrow the scope on the teamwork skills that are being looked for along with the theoretical lens for studying them in the context of this work.

With the increased adoption of work in groups and teams that incorporate autonomy in their designs, the importance of understanding the relationship between autonomy and group effectiveness has only increased (Langfred, 2000). Effectiveness is needed to be understood not only in workgroups across the industry but also in education (Johnson & Johnson, 1999). Autonomy is also a key point for promoting teamwork (Adler and Cole, 1993; Barker, 1993; Goodman et al.,1988; Sheridan, 1991; Strauss, 1955; Deci and Ryan, 1987;Hackman, 1983; Loheret al., 1985; Spector, 1986; as cited in Langfred, 2000). A group may have full discretion on what tasks they want to perform and the best way to carry them out. This definition not only helps understand teams better but also fits perfectly on the nature of Agile Software teams. A group that is completely independent and decide on the best way to perform their tasks, is a sign of a team with highly autonomous individuals. These two characteristics of a team, both group and individual autonomy, have a high relation with team effectiveness (Langfred, 2000).

Most studies argue about the positive effects of self-managing teams, while some present mixed results regarding the levels of autonomy (Guzzo and Dickinson, 1996; Kirkman and Rosen, 1999; Langfred, 2000; Tata and Prasad, 2004; Uhl-Bien and Graen, 1998; as cited in Moe et al., 2010). When a team as a whole is given a great deal of autonomy, it may not follow that the individual team members are given high levels of individual autonomy (Moe et al., 2010). Nonetheless, a team effort and individuals' orientation towards performance serve as a moderator between the group and individuals' autonomy (Langfred, 2000).

2.1 Teamwork in the Software Industry

Teamwork adds an extra layer of complexity into everything that already entails being part of a software project. If software engineering was a one-man job, coping with the uprising challenges of the tech world would be easier, but software engineering is a highly collaborative profession (Dullemond, Van Gameren, & Van Solingen, 2014). Social interactions represent a big part of the average day of software engineers. It has been estimated that more than half their day is spent on activities that include some form of collaboration with others, from representing and communicating design decisions and ideas, to communicating and negotiating with various stakeholders. Nevertheless, collaboration is downright essential to software teams (Dullemond et al., 2014).

In the late ‘90s, multiple companies started to identify a pattern in software projects. The big complexity in the projects, the poor communication between different stakeholders and the changing nature of software projects, started to cause a disconnection between teams and individuals, diminishing overall teamwork (Rising & Janoff, 2000). In consequence, these companies started to experiment with Scrum, a software methodology that was specifically designed to address the aforementioned issues. Scrum, as defined by its creators, is a framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value (Schwaber & Sutherland, 2017).

In general terms, Scrum is an approach to software development that encompasses a lot of elements that are not new to software development, an incremental time-boxed development approach (Rising & Janoff, 2000). Nonetheless, it introduced some game changers that directly addressed the issues that were causing poor teamwork effectiveness by changing how communication and collaboration occurred within software teams and between stakeholders. In addition, Scrum introduced a new way to view leadership in software teams, making the team structure completely horizontal.

The definition of self-managing teams presented in the previous section fits perfectly with how teams are described in software Agile practices, specifically in Scrum (Schwaber & Sutherland, 2017). Scrum not only is designed for teams that choose how to best accomplish their work, but it

has its own way to address the autonomy conflicts highlighted by previous research (Langfred, 2000). Scrum does so by introducing certain leadership roles among the team to aid in the shared goals, or as described by the Scrum framework, a "servant-leader", offering a certain form of control of the individual work among the team.

2.2 Teamwork in Education

Cooperative learning is a learning approach which promotes students working in small groups and receive rewards or recognition based on their group performance (Slavin, 1980). Furthermore, cooperative learning is at the heart or problem-based learning, emphasizing in the "natural learning," the one that occurs as the result of students working together in unstructured groups (Johnson, Johnson, & Smith, 1998).

Whenever individuals interact, there is potential for cooperation, but for it to occur certain conditions need to be met for real cooperation to exist (Johnson et al., 1998). There are 5 key elements that are critical for cooperation and teamwork: Positive interdependence, individual accountability, promotive interaction, social skills, and group processing. A brief description of the elements of cooperative learning is provided by Johnson, Johnson, and Smith (1998):

1. Positive interdependence: Ensure that each team member understands that the individual cannot succeed unless the others in the team do.
2. Individual accountability: Individual performance of each team member within the group is assessed.
3. Promotive Interaction: Team members promote one another's success by helping, assisting, supporting or encouraging one another's efforts to learn.
4. Social skills: Leadership, decision-making, trust-building, communication, and conflict-management skills need to be part of the team.
5. Group processing: Identification of ways to improve the processes that the team members have been using to maximize each other's learning.

Cooperative learning encompasses small-group teaching as a strategy in which learning takes place through group inquiry, discussion, and data gathering. In addition, this strategy is very high in

team members autonomy and involves a high degree of task interdependence because of the way work is assigned or distributed among team members (Slavin, 1980). Following this approach, and highlighting the previously presented key elements for cooperation, it is easier to understand how Agile Software methodologies like Scrum fit into learning environments where multiple dimensions regarding the learners need to be considered.

It is worth mentioning that the focus of this study was set in cooperative learning as defined by Johnson, Johnson and Smith (1998), which differs from collaborative learning in the how conditions for work coordination must be met (Dillenbourg, Baker, Blaye, & O'Malley, 1995). Collaborative learning supports a model on which individuals must coordinate efforts to solve the same problem (Dillenbourg, 2007). This level of coordination does not meet the nature of teams under the scope of this study, therefore the approach of cooperative learning is more suitable (Johnson et al., 1998).

The use of Agile Software methodologies is not new in the educational context, especially in ones where capstone projects are included. Previous work has shown that following Agile approaches is more appealing to student teams and resulted in greater project success (Umphress, Hendrix, and Cross, 2002; as cited in Magana et al., 2018), which is one of the main goals for looking at team characteristics. Properly aligning cooperative learning with Agile Software methodologies can serve as guidance for students to effectively analyze and design software solutions, as well to support the enactment of team characteristics that could serve as indicators for successful teams (Magana et al., 2018).

With the purpose of providing a better argument for alignment between the constructs explored in this study, the Table 2.1 describes how different team dimensions overlap between teamwork in general, teamwork in education and teamwork in the software industry:

Table 2.1: Alignment between team dimensions

Dimension	Teamwork	Teamwork in Education	Teamwork in Software
Group Composition	"A small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable". (Katzenbach & Smith, 1993, p. 112)	Cooperative learning occurs in small group settings (Johnson et al., 1998).	Scrum is a development process for small teams (Rising & Janoff, 2000).
Autonomy	A group may have full discretion on what tasks they want to perform and the best way to carry them out. (Langfred, 2000)	Key elements in cooperative learning (Johnson et al., 1998): • High individual autonomy. • High degree of task interdependency	Promotes self-organized teams that decide how to best accomplish their tasks (Schwaber & Sutherland, 2017).
Communication and Coordination	Dickinson and McIntyre (1997) highlighted: • Communication is the core mechanism that links all the other characteristics of teamwork. • Individuals ought to coordinate their efforts in order to attain a shared goal.	Social skills like leadership, decision-making, trust-building, communication, and conflict-management skills need to be part of the team (Johnson et al., 1998).	Scrum promotes horizontal communication in an open environment for teams to thrive (Schwaber & Sutherland, 2017).

Table 2.1 continued

Improvement and Achievement	Efforts to improve team performance need to focus their attention on the performance of individuals. However, these individuals are dependent on other team members to provide information and coordinate efforts (Dickinson & McIntyre, 1997).	Johnson, Johnson & Smith (1998) highlighted as key elements for cooperation: • Identify ways to improve team processes to maximize learning. • Team members promote one another's success by helping, assisting, supporting or encouraging one another's efforts to learn.	Scrum is an iterative and incremental framework that allows for teams to reflect and adjust in order to pursue their goals effectively (Schwaber & Sutherland, 2017).

Industry and academia need for better team performance suggests that supporting and enhancing team characteristics may result in better team performance. However, an initial step toward supporting team performance is to first define these team characteristics. Dickinson and McIntyre (1997) have proposed a framework that has been used to study software Agile teams (Moe et al., 2010),. Dickinson and McIntyre's framework (1997) provides a proper lens to study Agile software teams, since it was constructed by adjusting observational studies in context of high-performing teams that were self-managing and autonomous in terms of operations. Dickinson and McIntyre built upon previous work (Brannick, Salas, & Prince, 1997; Flanagan, 1954) done with the anti-air warfare (AAW) team of a Navy ship. They developed their teamwork measures through an iterative process incorporating both the teamwork model and data by following four major stages. First, they aligned with the critical incident method proposed by Flanagan (1954) to determine behavioral statements. Second, they conducted a clarification of these behavioral statements to make sure the statements were consistent across multiple measures. Third, they made sure that the behavioral statements matched teamwork components defined by experts in the field. Last, they constructed the teamwork measures that successfully matched their original teamwork components.

CHAPTER 3. THEORETICAL FRAMEWORK

Successful achievement of goals often requires several individuals to interact and work together as a team. A critical component of teams is that individuals ought to coordinate their efforts in order to attain a shared goal (Dickinson & McIntyre, 1997). Therefore, efforts to improve team performance need to focus their attention on the performance of individuals. However, these individuals are dependent on other team members to provide information and coordinate efforts (Dickinson & McIntyre, 1997). These collective efforts to improve performance, provide and share information, and coordinate work are teamwork.

Dickinson and McIntyre (1997) presented a conceptual framework for developing teamwork measures that can be used to endure effective individual and team performance. In the process for creating their framework, Dickinson and McIntyre (1997) ensured scientific rigor. For instance, various facets of reliability were considered and discussed in order to assess teamwork measures. The framework was built by conducting multiple stages of face validity and iterating it among different subject experts. Furthermore, they also thoroughly described the validation procedures, as well as the development of a base of inferences for the interpretation of teamwork measures.

Based on research efforts and previous review, Dickinson and McIntyre (1997) identified and defined seven core components of teamwork. These components and their relationships are described next (See Figure 3.1):

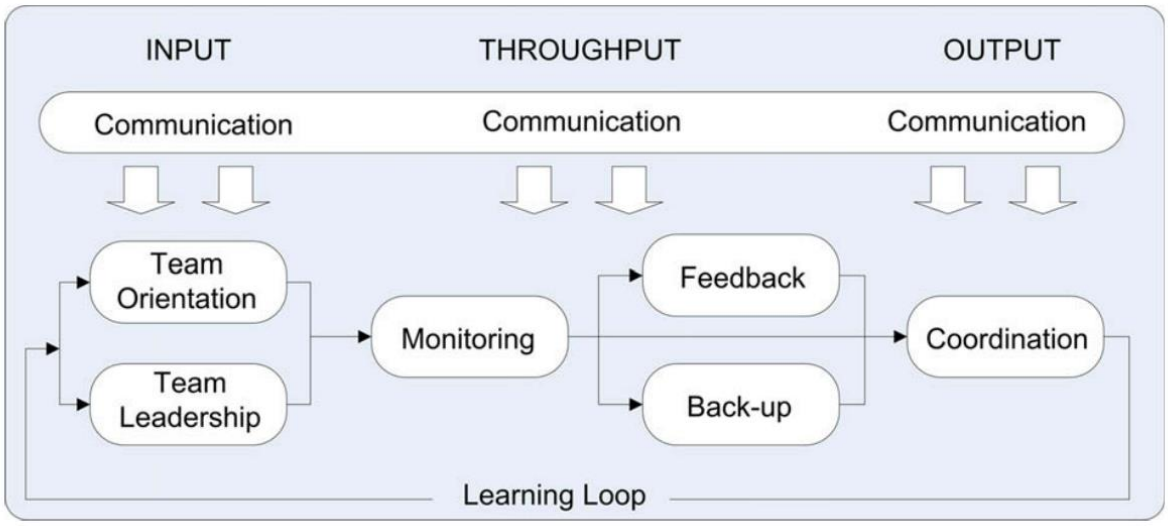


Figure 3.1: The Dickinson and McIntyre teamwork model (1997)

Communication is one of the major characteristics that involve teamwork processes. It involves the active exchange of information between team members. In general, communication is the core mechanism that links all the other characteristics of teamwork. For example, it is the link between actively monitoring team performance and providing feedback on said performance (McIntyre et al., 1989; as cited in Dickinson & McIntyre, 1997).

A second critical characteristic of teamwork is team orientation (Dickinson & McIntyre, 1997). Team orientation refers to the set of attitudes that team members have towards each other, the task in common, and their leader. It also includes self-awareness as a team member (Dyer, 1984; McIntyre et al., 1989; as cited in Dickinson & McIntyre, 1997), along with group cohesiveness (Nieva et al., 1978; as cited in Dickinson & McIntyre, 1997).

Team leadership is another critical characteristic of teamwork (Dickinson & McIntyre, 1997). Leadership as the formal direction and instructions provided by established leadership, as well as the leadership enacted by other team members (Glanzer et. al., 1956; Larson & LaFasto, 1989; as cited in Dickinson & McIntyre, 1997). Thus, leadership implies that the planned and directed activities elicit a response in the behavior of other team members.

Monitoring performance is a crucial component of teamwork (Cooper, Shiflett, Korotkin, & Fleishman, 1984; McIntyre et al., 1989, 1990; as cited in Dickinson & McIntyre, 1997). This characteristic mainly refers to the observation and awareness of other team members' performance. The key to monitoring in teams is that team members are competent in their individual tasks and have a proper understanding of the tasks of other members (Dickinson & McIntyre, 1997). Accordingly, for a group of individuals to properly perform as a team, each member must have the technical knowledge and skills to perform their own task (Cooper et al., 1984; Genzer et al., 1956; Larson & LaFasto, 1989; as cited in Dickinson & McIntyre, 1997).

Feedback is a fifth critical characteristic of teamwork (Dickinson & McIntyre, 1997). Teams must be in permanent adaptation and constantly learn from their own performance. For this to happen, it requires that team members constantly give, seek, and receive feedback from and to each other (Dickinson & McIntyre, 1997).

Another critical characteristic of teamwork is backup behavior (Dickinson & McIntyre, 1997). This characteristic involves for team members to actually help each other to perform their tasks (McIntyre et al., 1989, 1990; Morgan et al., 1986; as cited in Dickinson & McIntyre, 1997). Backup behavior means that each team has a certain degree of task interchangeability among members (Genzer et al., 1956; as cited in Dickinson & McIntyre, 1997), and eagerness from individuals to seek and provide assistance (Denson, 1981; Dyer, 1984; Nieva et al., 1978; as cited in Dickinson & McIntyre, 1997).

The final characteristic of teamwork is coordination (Denson, 1981; Dyer, 1984; Morgan et al., 1986; as cited in Dickinson & McIntyre, 1997). Coordination is the reflection of team members responding as a function of each other's behavior. Successful coordination implies that the other teamwork characteristics are effectively put in place (Dickinson & McIntyre, 1997). Therefore, team performance is produced by the synchronized actions of individuals.

To summarize, for teamwork to properly occur, team members should have a positive attitude towards the team and the tasks, have been provided direction and support to accomplish these tasks, and are knowledgeable in their tasks and the ones assigned to other team members. These

characteristics enable team members to coordinate their activities by monitoring each other's' performance, communicating, and providing feedback and assistance when required. Thus, leaders and members focus on improving teamwork rather than individual performance (Dickinson & McIntyre, 1997).

CHAPTER 4. METHODS

Dickinson and McIntyre's work (1997) has been used as a reference to study team performance dynamics (Cooke, Kiekel, & Helm, 2001; Marks et al., 2001; Moe et al., 2010; Salas, Sims, et al., 2005; Schippers, Edmondson, & West, 2014). More importantly, this work has resulted in broad literature reviews and meta-analysis that have defined teamwork (Brannick et al., 1997; Salas, Stagl, et al., 2005; Salas et al., 2007). Furthermore, the Dickinson and McIntyre framework (1997) was key to examine how teamwork was key for a software project using the Scrum approach (Moe et al., 2010). Dickinson and McIntyre's previous work provide a good foundation for studying teams following a Scrum approach. However, this particular study extends this work by applying it to developing teams in educational settings by focusing in the following aspects: (a) What are the teamwork self-reported characteristics that account for successful team interactions? And (b) How do these self-reported teamwork skills change over time throughout a semester-long project?

4.1 Participants and Context

PURDUE University Polytechnic Institute offers a major in Computer and Information Technology, which aims to provide students with a wide knowledge of computer field applications to solve real-world problems. In this major, they are required to take the course CNIT-280 Systems Analysis and Design Methods. This is a required class offered in an active learning format (i.e. Active team work with class assignments), making it a single classroom with around 100 students each semester. The goal of the class is to provide with today's approaches used by information system developers to model solutions and then construct an acceptable design to implement a system solution and its functional prototype. The course is emphasized on techniques used to develop information systems, such as systems diagrams, prototyping, project management, and team interaction (Magana et al., 2018).

4.2 Procedures

The approximately 100 students in class are usually divided in teams of 5 people. These teams are presented with a case study to which they are required to conduct the planning, analysis and design stages of the Systems Development Life Cycle (SDLC). The work presented by the teams is reflected in multiple deliverables known as "Milestones" (See Appendix A). Each of these Milestones encompassed the work completed during the stages of the SDLC and each one required the team to write a team retrospective on the completed work. During the whole semester, each team needs to submit 4 Milestones with the corresponding retrospective, and a final project, which is the collection of the completed work after the whole semester.

After each Milestone submission, the students received formative feedback in no more than a week. This feedback highlighted the positive aspects of the submission, while offering corrective guidelines for the parts that needed improvement. Each team, once they reflected on the feedback, had a week to resubmit any changes that they considered key to address.

The teams follow the Scrum framework for Agile Software development, aiming to build a functional prototype that represents, to certain extent, the solution that they have come as a team for the case study. Following Scrum, the students will go through 5 Sprints (i.e. Project iterations) on which they are expected present a version of the prototype and increase its functionality after each cycle. The experienced lived during the Sprints simultaneously with the Milestones is also presented in the Team Retrospectives, giving a glimpse of the multiple team perceptions in 5 different moments during the semester. The semester concludes with students submitting all individual milestones combined in a single design document along with the project prototype.

This study focused on the work conducted during two semesters, Spring 2018 and Fall 2017. The Spring 2018 had 18 teams, and the Fall 2017 with 19 teams.

4.3 Data Collection Methods

The work done by Dickinson and McIntyre (1997) recommends the use of three separate formats for constructing teamwork measures: behavioral observation scales, behavioral summary scale,

and behavioral event. The behavioral observation and behavioral summary scale formats are numerical scales for measuring teamwork, whereas the behavioral event format is a checklist for showing the occurrence of critical events requiring teamwork.

The behavioral summary scales were the ones selected for this study due to their simplicity. These scales can also be used to rate the degree of teamwork displayed by a particular team and its members. However, the scales do not contain multiple items. They require the observer to rate each component of teamwork only once. Team's level of skill on each component is rated according to a 5-point scale ranging from 1 (*hardly any skill*) in this component of teamwork to 5 (*complete skill)* in this component of teamwork. It should be noted that the high (5), medium (3), and low (1) points on the scale also are anchored by very broad behavioral statements (i.e. summaries) to help illustrate and define the scale (Dickinson & McIntyre, 1997).

There are multiple implications by using this framework. Unfortunately, although the scales were developed to be graded in real time by an observer or a team of observers, in this case, the scales are being used to measure team reflections. Nonetheless, this makes the object of analysis stationery, aiding its reliability because of the stability over time. Some trustworthiness, reliability, and validity measures were considered for this study and are described in detail in section 4.5.

Since there is no space for observation, and the measures have to be taken from reflections made on paper by teams, the behavioral summary scales were adapted to ease up the scoring of team skills. Levels 2 and 4 were removed from the scale because of the lack of descriptors, leaving only high (5), medium (3), and low (1), given that these values are accompanied by broad behavioral statements, providing a better guide for the person scoring. Also, not present (0) was used to mark aspects of team skills which no evidence is displayed on the team retrospectives. Team retrospectives are therefore the main data collection instrument for this study.

Table 4.1 presents the prompts provided to students to write their team retrospectives.

Table 4.1 Team retrospectives

Planning: Think about the strategies you used to coordinate the work.
• How did you plan the organization of work for the milestone? • What were team members roles? • How were activities assigned to each team member and what was the justification for that? • How the communication was handled among team members?
Monitoring: Think about the way you collaborated as a team.
• What aspects of the team coordination/collaboration went well in this milestone? • What aspects of the team coordination/collaboration went wrong in this milestone? • What are possible concerns?
Evaluation: Think about the quality of the milestone just delivered.
• What do you think as a team was particularly good about the milestone you just completed? • What are areas or sections of the milestone that you just completed you think could be improved?
Plan of Action: You must commit to have something to improve every milestone.
• What are aspects you think can be done better for the next milestone in terms of team performance?

For purposes of this study, some other measurements were considered for each team so there can be more points of reference to compare between teams and between Milestones. These measurements are detailed in Table 4.2.

The core measurement are teamwork characteristics. These characteristics will be measured in terms of the conceptual framework proposed by Dickinson and McIntyre (1997), adapting their behavioral summary scale into a rubric that will be used to analyze each team retrospective. The details of this adaptation will be presented in section 4.4.

With the purpose of exploring changes in team performance that could account for the perceived changes in team characteristics, different performance indicators will be considered as part of the data analysis. As shown in table 4.2, team performance was measured by the grades on each Milestone, the grade increment, and the final functional prototype grade. The Milestone grade is calculated by averaging the grades between the two submissions allowed per Milestone. The first submission is based on student's initial understanding on the required items for each Milestone, and the second submission is based on the detailed feedback they receive on their first attempt.

The grade increment is the difference between the final grade obtained for the Milestone and the first attempt made.

Furthermore, to support the information gathered from the team retrospectives, students conduct a quantitative assessment of the quality of interaction between team members. This assessment accounts for the students' perception on how teamwork was distributed.

4.4 Data Scoring and Data Analysis Methods

Each team reflection was analyzed individually with the behavioral summary from Dickinson and McIntyre scale for each team skill. Then, each team will get a *Team Score* for each Milestone. The *Team Score* is the addition of the scores obtained in the skills *Orientation, Leadership and Coordination.* The last one, is constructed by the addition of *Monitoring, Feedback*, and *Backup Behavior*, as suggested by the Dickinson and McIntyre framework (1997). As it was mentioned in the implications for the framework, the scale developed was adjusted so the analysis of each team reflection could be done easier in terms of delimitation between scores. The rubric used for each skill comprised in the scaled is as described on Table 4.3

Once the Team Retrospectives are scored, descriptive statistics, on each construct, including all the information described in Table 4.2 will be presented, differentiating the two semesters of data collection (Spring 2018 and Fall 2018), split in the 5 Milestones so the changes throughout the semester can be observed.

Afterwards, regression models will be used to test the hypothesis of how teamwork characteristics affect team performance. This analysis will grant the basis to provide further understanding on how the change or enactment of each of the described team characteristics considered in this study might affect other variables like team interactions and team performance in different moments of the semester.

4.5 Trustworthiness, Validity, and Reliability Considerations

To guarantee the validity and the reliability of this study, several measures were taken in order to provide accurate results and guarantee that the findings of this study are relevant for the area of study.

The initial scoring of the 185 Team Retrospectives was conducted during the Summer of 2018. In order to guarantee the validity of the measures, a sample of 37 Team Retrospectives (20% of the population) was randomly selected to be scored again during the Summer of 2019. This re-scoring was conducted by the same person, serving as a way of intra-rater reliability. This process of rescoring the team retrospectives yielded that 30 of the 37 Team Retrospectives were scored equally, giving a reliability of 81.1% which is an acceptable percentage given the qualitative nature of the Team Retrospectives.

In terms of content validity, the structure of the Team Retrospectives (See Table 4.1) was designed and reviewed by 3 people with vast experience in teamwork and software methodologies. These 3 people belonged to the instructional team for the Systems Analysis and Design Methods class. Therefore, guaranteeing that the Team Retrospectives reflected adequate team interactions and a proper way to map these interactions to the studied teamwork characteristics. Regarding the rubric designed to score the Team Retrospectives, face validity measures were taken by reviewing and adjusting its content with the input of a Ph.D. in Engineering Education expert in learning and engagement, with experience in systems analysis and design, teamwork and software processes.

In order to provide a better understanding of how teamwork characteristics changed during the project and how these changes had an impact on performance, multiple triangulations measures were taken. First, the multiple performance measurements used in this study were conducted by multiple people with the use of a defined rubric (See Appendix B), this guaranteed cross-validation in the performance measures and bias reduction. Second, the use of performance measures to complement the team characteristics measures provided a deeper understanding of the relationship between teamwork and how its different characteristics might have affected performance.

Table 4.2 Data collection methods

Construct	Definition	Data Analysis Method
Teamwork Characteristics	Core characteristics of teamwork defined by Dickinson and McIntyre (1997) transformed into a rubric: • Team Leadership. • Team Orientation • Monitoring • Feedback • Backup Behavior • Coordination	Rubric scores for the team retrospectives submitted in each of the 5 Milestones. These scores were analyzed as a composite score of all the characteristics per team, and the change in the individual characteristics per team throughout the semester.
Team Performance	Multiple performance indicators were considered: • Each Milestone first submission • Each Milestone definite grade • Milestone increment: The difference between the definite grade and the first grade. • Final functioning prototype grade	Descriptive statistics of the performance items will be presented. In addition, a correlation with the teamwork characteristics measurements and an analysis of how these indicators interact.

Table 4.3 Teamwork skills rubric

Team Skill	Low (1)	Medium (3)	High (5)
Orientation	Team members do not acknowledge the team as essential and merely complete the individual tasks assigned.	Team members split work and accomplish task individually, are willing to reflect and work as a team if asked to.	Team members reflects high acceptance of team norms, assigns high priority to the team goals, and willingly participates in all relevant aspects of the team
Leadership	Team members do not get into leadership roles letting the team to move and progress by itself rather than by any form of direction.	Team members will provide some sort of directions if no visible leadership is happening and team progress is stalled. There is no structure or support provided for other team members	Team members involve in providing direction, structure, and support for other team members. Explain to others what is needed from them, and listen to concerns of other team members
Monitoring	Team members are competent but completely disregard other team members' performance	Team members are competent and will only engage in another member's performance if it is poor.	Team members are individually competent and are aware of others' performance. Recognizes when a team member performs correctly
Feedback	Team members do not seek performance information and do not respond to any form of suggestion or feedback	Team members only involve in seeking and receiving information regarding time-saving suggestions. No performance information is sought or offered.	Team members involve in giving, seeking and receiving information among members. They respond to other members' request for performance information
Backup Behavior	Team members are not accountable for other members' failures or mistakes	Team members understand other members' tasks and provide assistance when it requires mistake correction.	Team members are willing and able to provide and seek assistance when needed. They will fill in for another member who is unable to perform a task
Coordination		Refers to team members executing their activities in a timely and integrated manner. This may involve an exchange of information that subsequently influences another members' performance. Due to the nature of this skill, the measure is defined as the addition between monitoring, feedback and backup behavior. High coordination cannot be achieved if these skills are not developed among the team members.	

CHAPTER 5. RESULTS

To answer the research questions, a multi-method approach was used to analyze the data. First, descriptive statistics were used to provide central tendency and variability measures in multiple points of the project (See Table 5.1). Then, inferential statistics were used to determine relationships between team characteristics and understand how these characteristics changed across the semester, as reported by students.

Table 5.1: Descriptive statistics of each individual skill per Milestone

Descriptive Statistics							
Skill	**Milestone**		**1**	**2**	**3**	**4**	**5**
Orientation	**Fall 2017**	**Mean**	4.37	4.21	4.47	4.47	4.47
		SD	0.96	1.51	1.31	1.12	1.12
	Spring 2018	**Mean**	4.50	4.72	4.89	5.00	4.89
		SD	1.29	1.18	0.47	0.00	0.47
Leadership	**Fall 2017**	**Mean**	3.11	3.32	3.53	3.32	3.42
		SD	1.66	1.77	1.31	1.53	1.43
	Spring 2018	**Mean**	3.17	3.83	4.67	4.33	4.00
		SD	1.62	1.54	0.77	0.97	1.03
Monitoring	**Fall 2017**	**Mean**	3.58	3.58	4.47	4.05	4.05
		SD	1.61	1.30	1.12	1.22	1.39
	Spring 2018	**Mean**	3.17	3.61	3.56	3.33	3.11
		SD	1.89	1.91	1.79	1.97	1.75
Feedback	**Fall 2017**	**Mean**	2.21	2.74	3.00	3.32	3.11
		SD	1.72	1.69	1.63	1.53	1.82
	Spring 2018	**Mean**	2.06	2.50	2.33	2.67	3.00
		SD	1.63	1.69	1.68	1.71	1.53
Backup Behavior	**Fall 2017**	**Mean**	2.11	2.84	3.21	3.63	3.21
		SD	1.59	1.89	1.62	1.64	1.87
	Spring 2018	**Mean**	2.28	2.50	2.56	2.89	2.56
		SD	1.74	1.95	1.62	2.00	1.89
Coordination	**Fall 2017**	**Mean**	2.63	3.05	3.56	3.67	3.46
		SD	1.46	1.39	1.20	1.22	1.49
	Spring 2018	**Mean**	2.50	2.87	2.81	2.96	2.89
		SD	1.53	1.56	1.27	1.66	1.38

The first research question was RQ1: *What are the characteristics of students' self-reported teamwork experiences as part of a semester-long project?* To answer this question, the approach was using an existent framework that allowed measurements of different components of team work (Dickinson & McIntyre, 1997). The framework summarizes multiple studies that had previously analyzed the different characteristics and how the input variables influenced the teams.

Dickinson and McIntyre (1997) argued that the critical characteristic that encompasses teamwork is communication as the key connecting component between all the teamwork characteristics. The self-reported characteristics of teamwork are team orientation, team leadership, monitoring, feedback, backup behavior and coordination. All of them have been previously defined in the previous chapter. Successful team interactions are the constant enactment and adjustment that team members make of the aforementioned teamwork characteristics in a permanent learning loop, where the input, throughput and output are guided by communication (Dickinson & McIntyre, 1997). These characteristics can change and be adapted as needed by the team according to the situation being faced, they are not a static measure of teamwork but more a measure of the response that the team gives to a certain situation.

To answer the second research question *RQ2: How do these self-reported teamwork characteristics change over time throughout a semester-long project?* Excerpts from the team retrospectives are presented and examined under the rubric presented in the Methodology section of the current study. The elements presented are team orientation, team leadership, monitoring, feedback and backup behavior. Coordination is a composite measure, and communication is a given due to the nature of team interactions.

It is worth mentioning that each of the characteristic scores reflected a snapshot of the team during each Milestone. This snapshot was documented in the team retrospectives. It was thus assumed that team characteristics were dynamic and bounded to change through the project. Also, getting a high or a low score did not necessarily mean that a team was better or worse than other teams, it was simply a measure of how the teamwork characteristics were reported by each team on the retrospectives done at the end of each Milestone.

T-test were used to determine any significant difference in how each individual characteristic changed between the Fall 2017 and the Spring 2018 semester (See Table 5.2). These tests did not yield any significant difference except for Leadership during Milestones 3 and 4. Details of the difference between these Milestones and the reason behind this difference is covered in the discussion section of this study.

Table 5.2: T-test for Fall 2017 vs. Spring 2018

		Milestone				
Skill		**1**	**2**	**3**	**4**	**5**
Orientation	**t value**	0.35	1.15	1.30	2.04	1.48
	df	31.21	33.78	22.83	18.00	24.41
	p value	0.73	0.26	0.21	0.06	0.15
Leadership	**t value**	0.11	0.95	3.26	2.43	1.42
	df	34.97	34.79	29.36	30.68	32.74
	p value	0.91	0.35	**0.00**	**0.02**	0.16
Monitoring	**t value**	-0.71	0.06	-1.86	-1.33	-1.81
	df	33.49	29.80	28.34	28.14	32.53
	p value	0.48	0.95	0.07	0.20	0.08
Feedback	**t value**	-0.28	-0.43	-1.22	-1.21	-0.19
	df	35.00	34.90	34.75	34.03	34.54
	p value	0.78	0.67	0.23	0.23	0.85
Backup Behavior	**t value**	0.31	-0.54	-1.23	-1.23	-1.06
	df	34.29	34.76	34.90	32.96	34.87
	p value	0.76	0.59	0.23	0.23	0.30
Coordination	**t value**	-0.27	-0.38	-1.84	-1.47	-1.20
	df	34.66	34.04	34.58	31.14	34.98
	p value	0.79	0.71	0.08	0.15	0.24

This section is organized as follows. Each of the team characteristic is first presented along with samples of students' responses to the retrospective along with the corresponding score. Then, descriptive statistics are presented for each of the characteristics described for each individual milestone. The purpose of this section is to expand on the details encompassed in the *RQ2: How*

do these self-reported teamwork characteristics change over time throughout a semester-long project?

5.1 Team Orientation

To recall, team orientation refers to the set of attitudes that team members have towards each other, the task in common, and their leader (Dickinson & McIntyre, 1997).

The following excerpt is an example of how the descriptor for Low (1) fits by emphasizing the individual task completion:

> *"Each team member chose what they wanted to do and did them accordingly. This was justified by allowing team members to do what they were comfortable with, rather than being forced into roles they didn't feel they were able to fill."*

In this excerpt of a team reflection it can be noted how teamwork was split and accomplish individually, to later be merged. The following excerpt fits the descriptor for Medium (3) team orientation:

> *"…We initially worked individually to brainstorm ideas for case requirements and then came together to merge them and come to a finished requirements list." […]*

Finally, looking into the descriptor for High (5) team orientation can be more challenging due to the subtlety in the language, but the following excerpt will prove useful to understand how this descriptor was scored across the multiple reflections:

> *"We plan on the organization of work for the milestone by looking at the due date for each milestone and have several checkpoints before the milestone is due. There be certain tasks that we need to have finished by that checkpoint so that the project will be completed in time. We assigned activities to each team member by looking at the project workload and then divided the milestone in a way that made sure that everyone's workload was equal so this way one person is not doing the entire project by themselves." […]*

In terms of team orientation, Figure 5.1 details how the skill changed during the team project:

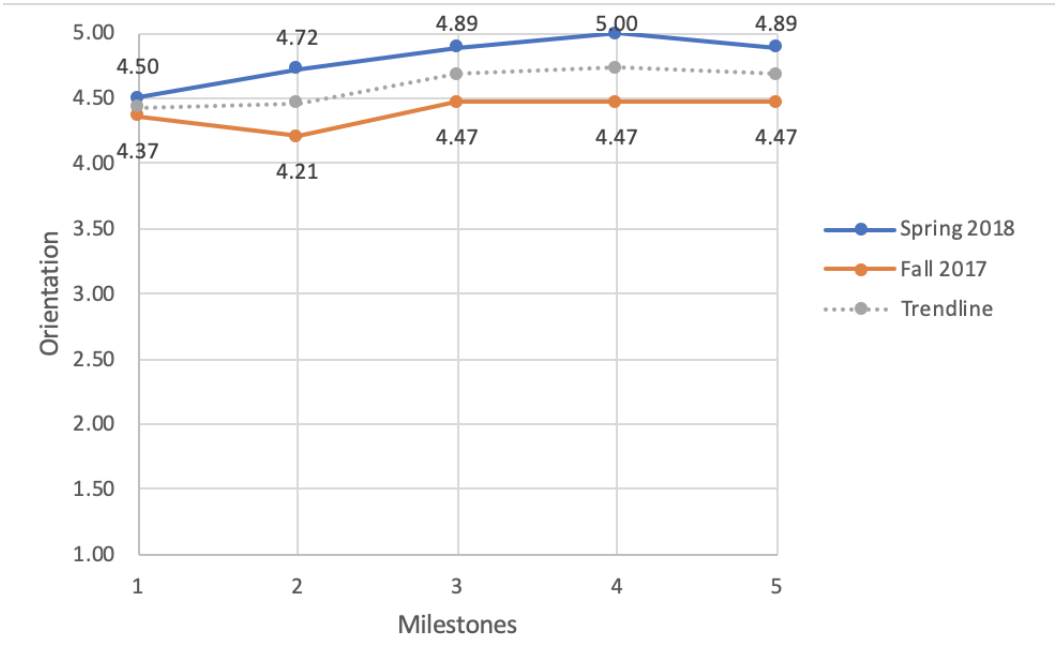


Figure 5.1: Team Orientation throughout the semester-long project

Accounting for the two terms examined during this study, both semesters' groups averages were quite close to each other with a minimum score of 4.21 (Milestone 2, Fall 2017). Nonetheless, the project methodologies used during Spring 2018, where students were guided to better enact Scrum principles, show that members tended to display a bigger orientation towards the team, higher than the methodologies used during Fall 2017. Furthermore, in both cases, the overall tendency was to increase the score while the project advances, this could be caused by the increased rapport between the team members and the positive interactions between them.

5.2 Team Leadership

Leadership was referred to as the formal direction and instructions provided by established leadership, as well as the leadership enacted by other team members (Glanzer et. al., 1956; Larson & LaFasto, 1989; as cited in Dickinson & McIntyre, 1997).

The following excerpt is an example of how the descriptor for Low (1) team leadership fits by emphasizing how the team moves by itself rather than by leadership:

> *"The roles for this milestone were determined by the individual members during each meeting." […]*

In the following excerpt, it can be noted how leadership only occurs when the work gets stale, fitting the descriptor for Medium (3) team leadership:

> *"… We first set the expectation of how much of the workload needed to be completed by each individual, and then everyone chose which parts they wanted to do. In cases where there were fewer tasks than there were people, those who did not get to volunteer for a part were tasked with assisting those who did." […]*

The descriptor for High (5) team leadership can be evidenced in the following excerpt, especially when it comes to provide direction and structure:

> *"We planned on the organization of work for the milestone by splitting each of the necessary requirements equally amongst each of the group members. We assigned activities to each team member by looking at the project workload and then divided the milestone in a way that made sure that everyone's workload was equal so this way one person is not doing the entire project by themselves. We required around two checkpoints. The first checkpoint was to make sure that at least half of the work was done for each of the required parts assigned to each team member." […]*

As detailed in Figure 5.2, the leadership skill for the study changed in the following way:

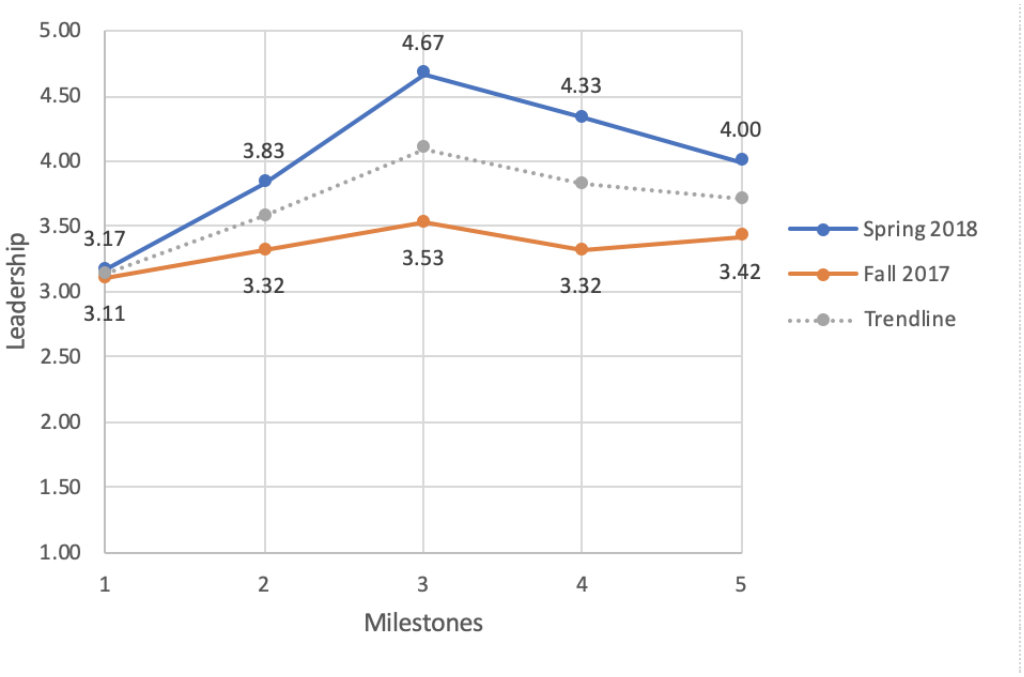


Figure 5.2: Team Leadership throughout the semester-long project

Overall, the difference between leadership for the two terms examined is more significant. During Spring 2018 there is a higher evidence of leadership, which tends to decrease during the end of the semester. It could be accounted for an increased need for intervention on how the work was being handled by the teams. For Fall 2017, the leadership score is lower across the whole project, but it is much more stable compared to the other term.

5.3 Monitoring

Monitoring mainly refers to the observation and awareness of other team members' performance (Dickinson & McIntyre, 1997).

The following excerpt is an example of how the scope of team members is only limited to their own work, which would fit the descriptor for Low (1) monitoring:

> *"The organization of the work wasn't necessarily divided into roles, more specifically, team members simply did what they could when they could."*

In the next excerpt from a team reflection, it can be highlighted how team members only engaged in the parts were performance was poor, fitting the descriptor for Medium (3) monitoring:

> *"I think as a team we were able to improve our milestone, by looking at what we did wrong previously and then improving it." […]*

In the following excerpt, it can be noted how the team engages and highlights the performance of the team while monitoring teamwork, fitting the descriptor for High (5) monitoring:

> *"Each team member completed their assigned tasks without problems, and go their portion of the work done with quality and punctuality. Team members could collaborate earlier in order to more quickly catch inconsistencies in formatting diagrams."*

Monitoring across the semester for both terms, as illustrated by Figure 5.3:

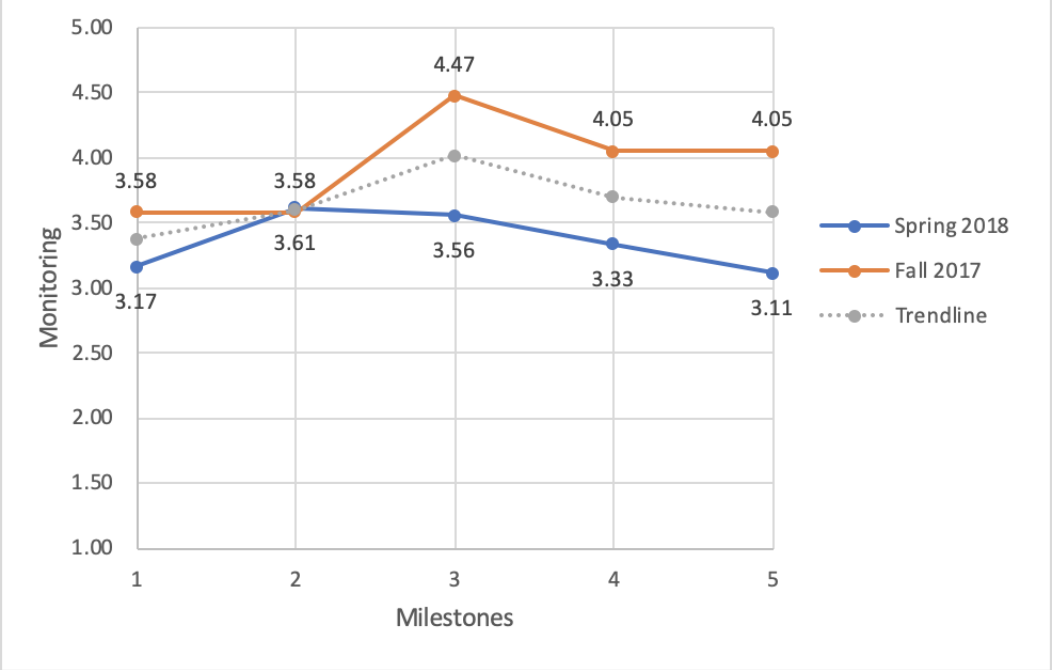


Figure 5.3: Monitoring throughout the semester-long project

During Spring 2018, the monitoring between team members tended to be lower than the one in Fall 2017, decreasing as the project advanced. On the other hand, Fall 2017 had a major increase after Milestone 2, stabilizing by the second half of the project.

5.4 Feedback

Feedback refers to how teams must be in permanent adaptation and constantly learn from their own performance. For this to happen, it requires that team members constantly give, seek, and receive feedback from and to each other (Dickinson & McIntyre, 1997).

Measuring feedback proved to be trickier, since there would not be a perfect fit for the descriptor of Low (1) feedback because it is more of an observational feature. Nonetheless, the decision was to fit in this descriptor any form of feedback that did not offer a plan of action. One excerpt that exemplifies this behavior is:

> *"…Things that went wrong: plan timing for the project." […]*

Measuring higher levels of feedback is easier to evidence in the team reflections. The following excerpt fits the descriptor for Medium (3) feedback, highlighting time management comments:

> *"What went wrong: hard to schedule a single time for all group members to meet, delayed working until close to the deadline due to conflicting schedules. Concerns: finding a time slot that meets all members' schedules, not being able to finish on time due to procrastination."*

The descriptor for High (5) feedback involves the giving and seeking of information. In the following excerpt it can be highlighted this dynamic of information as a way to be held accountable:

> *"…Each team member should play an active role in keeping the team on track, well-informed, and evaluating submitted work. Because each team member has a different schedule, it will be expected of other team members to be understanding of any exams while*

still holding the absent team member accountable. For the next milestone, each team member should review the entire document, and then the team can make changes to the milestone elements in order to make it more uniform and to avoid any errors in small details. Team members should also be sure to attend key project-working classes so that work can be distributed more evenly and each member is contributing the same or close to the same amount."

As detailed in Figure 5.4, feedback across the study changed as follows:

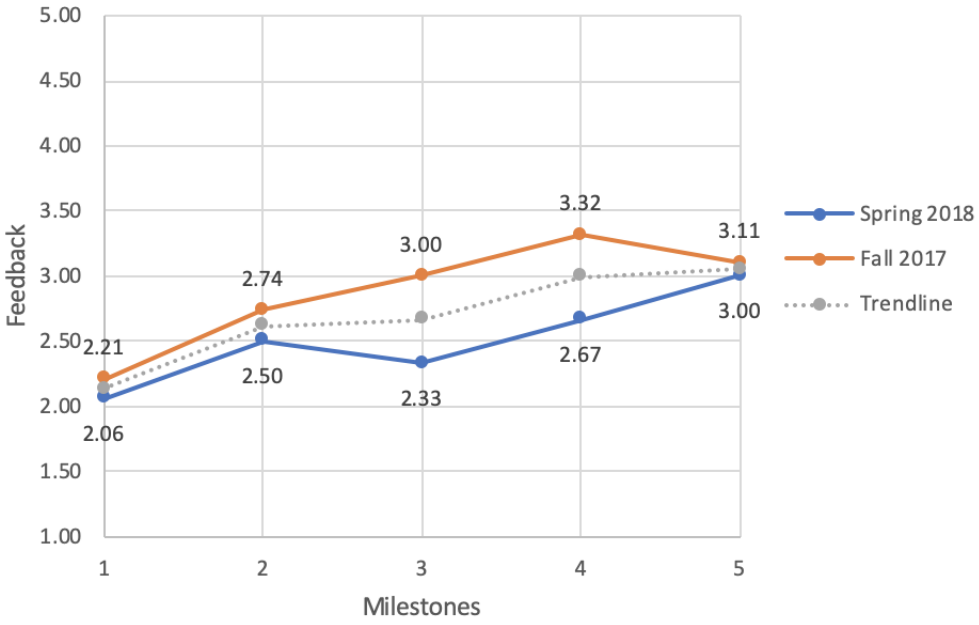


Figure 5.4: Feedback throughout the semester-long project

In terms of feedback, the scores for both terms were close to each other and tended to increase as the project advanced, which could denote a higher need in giving and seeking information, especially around time-saving suggestions.

5.5 Backup Behavior

Backup behavior involves for team members to actually help each other to perform their tasks (McIntyre et al., 1989, 1990; Morgan et al., 1986; as cited in Dickinson & McIntyre, 1997). Backup

behavior means that each team has a certain degree of task interchangeability among members (Genzer et al., 1956; as cited in Dickinson & McIntyre, 1997).

Trying to identify where a Low (1) backup behavior is displayed on a team can be difficult without direct observation. In this case, this score was assigned to teams that identified possible needs for backup but did not address how to handle the situation, as it can be seen in the following excerpt:

> *"…A possible concern for the future is availability of members to practice for the final presentation due to busy finals schedules."*

Identifying behaviors that will match the descriptor for Medium (3) backup behavior is easier, as it can be noted in the following excerpt focusing in mistake correction:

> *"…As time passed the group did become a little less tolerant of people not pulling their weight. This resulted in the group altering so that it was more individualized."*

In terms of measuring High (5) backup behavior, the focus was more towards identifying teams that were willing to seek and provide assistance. The following excerpt is an example of that:

> *"…We all had our certain areas that we focused on particularly when it came to the project, but the majority of our work was done together, in person. We worked very well together because we all had different ideas that converged together to form a bigger picture; we all had a similar goal in mind. We were good at planning ahead of time what needed to be accomplished and acting on that." […]*

Overall, the backup behavior changed during the whole project as shown in Figure 5.5:

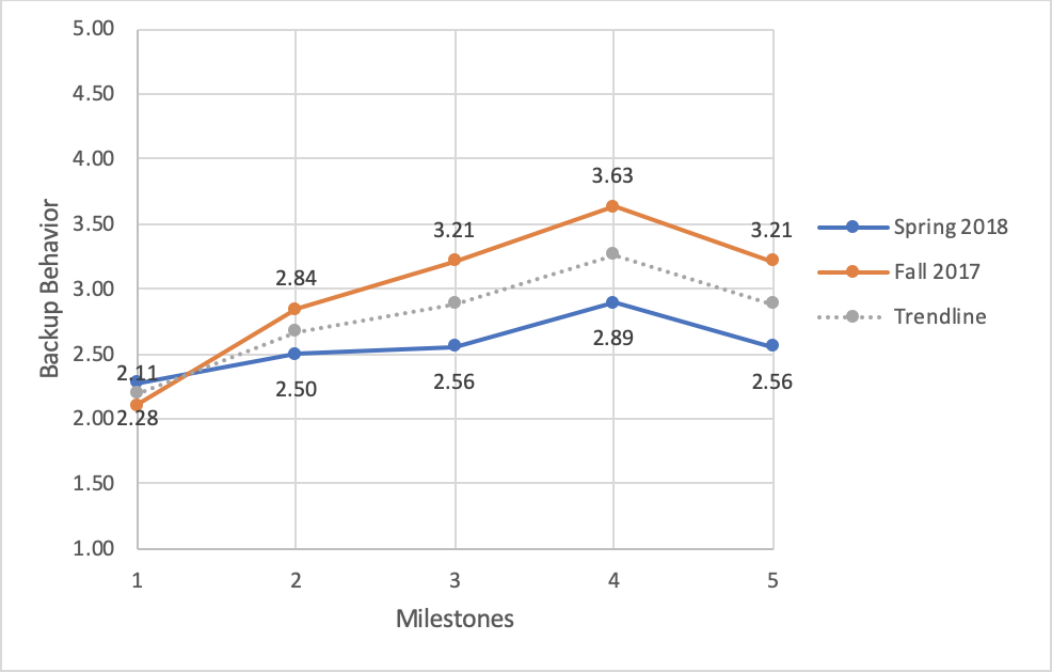


Figure 5.5: Backup Behavior throughout the semester-long project

Both terms increased their backup behaviors as the project advanced. However, the tendency to increase was higher during Fall 2017 than Spring 2018. Both terms peaked during Milestone 4, which coincide in the academic calendar with some final deadlines for other classes, which could explain the need for backup in the team.

5.6 Coordination

As explained in the rubric (See Table 4.3), coordination is measured as the combination of monitoring, feedback, and backup behavior. Yet, a comparison between both terms was made to get a broader understanding. Figure 5.6 shows how these skills interacted as a single score:

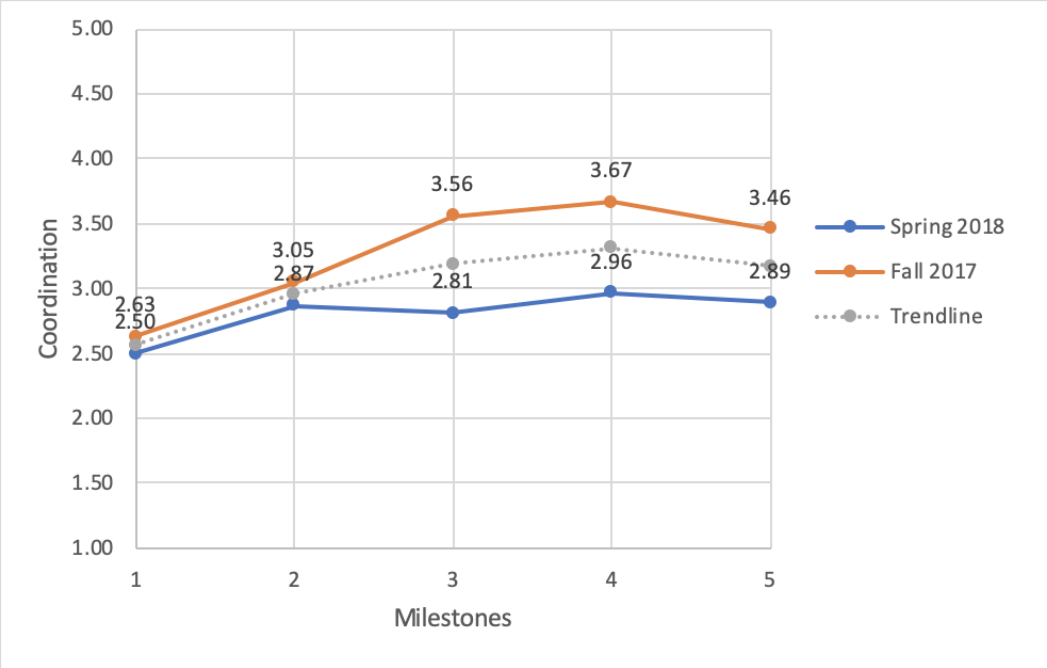


Figure 5.6: Coordination throughout the semester-long project

As it can be seen in Figure 5.6, the coordination score was much higher for Fall 2017 than Spring 2018. In the latter, the score is much more stable across the project, which could denote more stable team dynamics, while in the former, it could mean a higher need for adjustments.

5.7 Holistic Analysis

Now, under the scope of the third research question *RQ3: Which of these self-reported teamwork characteristics were the most impactful on overall team performance during a semester-long project?* A holistic approach was followed to conduct an analysis that could make more sense of how and why these self-reported teamwork characteristics changed.

First, a Pearson correlation was used to determine the possible relationships between each individual teamwork characteristics and the performance measures being considered in the study for each Milestone. The correlation matrixes (See Appendices C through H) showed some indications on how certain characteristics were more prominent to show a strong connection with the grade for each Milestone. Each matrix uses a color scale described in the right side, indicating

the strength of the relationship. A strong orange color means a value of -1, and a strong blue color means a value of 1. The absence of color means 0 or not relationship whatsoever. The different patterns and relationships showed indications of how the individual characteristics might be affecting performance in different ways given the nature of each Milestone. Therefore, further analysis was required to understand these possible relationships.

For each semester considered in this study, and each Milestone, a regression analysis was conducted in order to expand on the relationship indications found in the Pearson correlation. Every respective regression model was built using the Milestone grade as the response variable, and each teamwork characteristics as predictors. Afterwards, backward elimination was used to adjust the regression model while monitoring the F-statistic and the R squared.

To understand the baseline of the performance measures (i.e. Grades) the detailed rubric for each Milestone was provided in the Appendix B.

Analyzing the details of each Milestone submission, Milestone 5 was dropped from the regression models because of the nature of the submission. Milestone 5 is a compilation of all the work accomplished during the semester-long project by the teams and it doesn´t require new information or work, therefore, the enactment of teamwork skills during this submission will not provide an accurate measure.

For the Fall 2017 semester, the regression models were adjusted as detailed in Table 5.1:

Table 5.3: Regression models Fall 2017

Fall 2017				
Team Characteristic	M1	M2	M3	M4
	β(SE)	β(SE)	β(SE)	β(SE)
Orientation	-0.18 (0.075)		0.14 (0.092)	
Leadership Monitoring	-0.16 (0.082)		-0.19 (0.154)	
Feedback Backup Behavior				
Coordination	0.15 (0.090)		0.26 (0.141)	
Df	3,15	N/A	3,15	N/A
R^2	0.375	N/A	0.285	N/A
F	3.004	N/A	3.004	N/A

- Milestone 1: The results of the regression explained 37.53% of the variance of the model ($R^2 = 0.3753, F(3,15) = 3.004, p < 0.05$). It was found that team orientation ($\beta = -0.18, p < 0.01$), monitoring ($\beta = -0.16, p < 0.05$), and coordination ($\beta = 0.15, p < 0.1$) significantly predicted the performance measure.

- Milestone 2: The results of the regression did not explain any significant connection between the teamwork characteristics and the performance measure.

- Milestone 3: The results of the regression explained 28.47% of the variance of the model ($R^2 = 0.2847, F(3,15) = 3.004, p < 0.1$). It was found that team orientation ($\beta = 0.14, p < 0.1$), monitoring ($\beta = -0.19, p < 0.1$), and coordination ($\beta = 0.26, p < 0.1$) significantly predicted the performance measure.

- Milestone 4: The results of the regression did not explain any significant connection between the teamwork characteristics and the performance measure.

For the Spring 2018 semester, the regression models were adjusted as detailed in Table 5.2:

Table 5.4: Regression models Spring 2018

Spring 2018				
Team Characteristic	M1 β(SE)	M2 β(SE)	M3 β(SE)	M4 β(SE)
Orientation				
Leadership				-0.08 (0.059)
Monitoring	-0.13 (0.057)	0.07 (0.088)	-0.06 (0.020)	0.05 (0.029)
Feedback	0.18(0.066)			
Backup Behavior				
Coordination		-0.19 (0.108)		
Df	2,15	2,15	1,16	2,15
R^2	0.356	0.253	0.369	0.226
F	4.144	2.538	9.337	2.189

- Milestone 1: The results of the regression explained 35.59% of the variance of the model ($R^2 = 0.3559, F(2,15) = 4.144, p < 0.05$) . It was found that monitoring ($\beta = -0.13, p < 0.05$) , and feedback ($\beta = 0.18, p < 0.05$) significantly predicted the performance measure.

- Milestone 2: The results of the regression explained 25.29% of the variance of the model ($R^2 = 0.2529, F(2,15) = 2.538, p < 0.1$). It was found that monitoring ($\beta = 0.07, p < 0.1$) , and coordination ($\beta = -0.19, p < 0.1$) significantly predicted the performance measure.

- Milestone 3: The results of the regression explained 36.85% of the variance of the model ($R^2 = 0.3685, F(1,16) = 9.337, p < 0.01$) . It was found that monitoring ($\beta = -0.06, p < 0.01$) significantly predicted the performance measure.

- Milestone 4: The results of the regression explained 22.59% of the variance of the model ($R^2 = 0.2259, F(2,15) = 2.189, p < 0.1$) . It was found that team leadership ($\beta = -0.08, p < 0.1$) , and monitoring ($\beta = 0.05, p < 0.1$) significantly predicted the performance measure.

As it can be noted by the previous results, the regression models for the Fall 2017 semester are not strong nor consistent in how the teamwork characteristics truly predict the performance measures for each Milestone. Nonetheless, the regression models for the Spring 2018 semester showed more promising results.

It is important to highlight that the regression models were created for each semester considering the teams' initial submissions and the resubmission, but the difference in the models were not significant. Thus, the information presented is based on the initial submissions because it represents a more adjusted result for the teamwork performance without introducing any possible bias from the feedback provided for the resubmission.

Despite each regression model being different, there was a pattern that remained and was how large part of the performance variability for each milestone could be predicted by the enactment of monitoring, more so noticeable during the Spring 2018 semester. In some cases, monitoring will appear accompanied by other teamwork characteristics, but this behavior in the regression models was different for each Milestone.

The other measure that was considered as part of the holistic analysis were the Milestone increments. As presented in Table 4.2, the increment is the difference between the resubmission and the initial submission for each Milestone. The same procedure was followed for each Milestone increments, and regression models were used with said increments as the response variable and each team characteristic as the predictors for the model.

For both semesters, the regression models could not effectively determine a strong fit on how the enactment of the teamwork characteristics could predict the increment for the teams. However, while performing the backward elimination process for the regressions, on each case, the first team characteristic to be removed from the model due to being the least significant, was team leadership. This behavior for each regression model could explain some of the individual characteristic behaviors presented in the previous subsections of this chapter.

Further interpretation of the results are presented in the discussion section so the information can be properly placed in context of the literature and the study.

CHAPTER 6. DISCUSSION

The purpose of this discussion chapter is to guide the findings of this study regarding the characterization of teamwork self-reported characteristics, how these characteristics changed throughout a semester-long project, and which of these characteristics were the most impactful to the overall performance of the teams.

First, the discussion is guided towards the indications and possible reasons behind the changes in the individual teamwork characteristics presented in this study. Next, how the changes in these teamwork characteristics may be interrelated, and how the enactment of the aforementioned characteristics may have affected one another. Afterwards, the discussion shifts towards the indications on how the processes defined in the Scrum framework might have had an impact on team effectiveness. In the same way, this opens to the argument on how autonomy, both in the group and the individual level, and self-managing teams might have had a high relationship with team effectiveness as well. The connections between autonomy and self-managing teams guided the discussion to the role of team leadership in the context of Scrum and software teams, along with the key aspects of this role in moderating the different levels of autonomy within a team. Finally, the discussion is centered on the impact that team characteristics might have had on the overall performance of a team, situating said impact on the context of software teams and the implications of this impact in future studies of teamwork.

6.1 Teamwork Characteristics

It is key to highlight that team orientation, team leadership, and team coordination had their own unique dimensions. Monitoring, feedback, and backup behavior were all teamwork characteristics considered as part of the coordination efforts of a team to achieve their goal.

Team orientation had an interesting connotation in the two semesters analyzed in this study. In both cases, team orientation had a tendency to increase as the semester advanced. As highlighted

in the results chapter (See Figure 5.1), this could be a consequence of increased team rapport between each team member. Furthermore, once team members started grasping the inherent complexity of a software project, their awareness for the need of task interdependency increased. This increase in task interdependency is a key set up for proper cooperation to happen (Johnson et al., 1998). Thus, team members had an increased sense of membership due to the aforementioned cooperation, aiding in this way team cohesiveness. Team cohesiveness can ultimately be translated into increased team effectiveness (Guzzo & Dickson, 1996). The latter was evidenced by the fact that all teams, during both semesters, performed and delivered acceptable projects according to the expectations of the course (See Appendix B).

Team leadership was enacted in different ways during both terms. The trend in leadership was higher for the Spring 2018 semester than the Fall 2017 semester. There can be multiple implications around this difference. Regarding the overall pattern that the two semesters followed, leadership reached its higher peak during Milestone 3. This Milestone was the one that required the most amount of work, not only because of the large number of deliverables, but also because of its complexity. The increased amount of work could account for an increased need of instructions among team members.

Focusing on the difference in leadership during both semesters, there are some interesting patterns in the team coordination characteristics (i.e. Monitoring, feedback and backup behavior). In general, when teams enacted higher levels of leadership, the levels of the coordination characteristics tended to be lower. This pattern is noticeable with the trends presented in the results chapter (See Figure 5.6). During the Spring 2018 semester, team leadership is overall higher than the Fall 2017 semester. Accordingly, the trend in monitoring, feedback and backup behavior for the Spring 2018 is overall lower than the trend for the Fall 2017 semester. This difference suggests how a clearly defined leadership can support team effectiveness and set up teams to require less adjustments along the way (Rising & Janoff, 2000; Schwaber & Sutherland, 2017). In addition, this denoted difference may support how leadership can be key for successful cooperation between team members (Johnson et al., 1998).

There are other aspects of leadership that need to be considered in this discussion. Leadership is a key term that is highlighted in most teamwork literature, and in the case of this specific study, it had multiple connections with other findings. For instance, both monitoring and feedback as individual team characteristics, did not follow any uncommon pattern. The two of them had a tendency to increase during the semester-long project. These behaviors most likely can be explained by the increase in complexity of the deliverables being requested in advanced stages of the project (See Appendix A). Nonetheless, monitoring provided some key insight in the regression analysis.

Monitoring, in the regression analysis, had an interesting behavior regarding the way it contributed to the variability of performance. In Milestone 1 and Milestone 3, the contribution is negative. This can be translated into higher levels of monitoring during these milestones, which predict negatively in overall performance. This behavior can be explained by the nature of the work expected during these Milestones. Milestones 1 and 3 had the highest number of individual work components from the project, requiring students to put some extra effort in the completion of these components. Furthermore, the complexity of these individual components was greater than the others (See Appendix A), usually causing students to struggle and require other team members to monitor and intervene in their work.

Monitoring, during Milestones 2 and 4, had a positive impact on the overall variability of performance. This behavior can be explained by the nature of the deliverables which were more a compilation of work that was completed in previous Milestones. The monitoring role in these Milestones was more focused towards making sure the whole team was aligned with the final submission.

Backup behavior had an interesting place in this analysis. Both semesters analyzed during this study showed an increase in backup behavior during the development of the project. It is worth highlighting that the denoted difference between the Spring 2018 and Fall 2017 semesters followed the leadership pattern that was previously mentioned in this chapter. In general, when teams enacted higher levels of leadership, the levels of the coordination characteristics tended to be lower. Backup behavior peaked during Milestone 4. This peak was caused due to the overlap of academic

activities. Most of other classes' final projects were also due during the same time that Milestone 4 was due, requiring teams to adjust their workflow and backup team members that needed assistance.

Coordination is the composite score of monitoring, feedback and backup behavior. The composite score for coordination followed a similar pattern to leadership. A team that enacted higher levels of leadership required lower levels of coordination.

6.2 Scrum processes

As mentioned before, Scrum is a software development approach that encompasses a lot of elements that are not new to software development. Nonetheless, the key successful factor of Scrum is that it often addresses different aspects that directly affect team effectiveness (Rising & Janoff, 2000). Scrum does a great deal in establishing clear processes for teamwork and team interactions. It defines the way communication should and how often occur between team members (i.e. Daily 20-minute meetings). Furthermore, Scrum sets ground rules for how team members should enact leadership. For example, it defines the specific role of a "servant-leader" that should promote team orientation and eliminate barriers (Schwaber & Sutherland, 2017).

Using the Scrum approach for well-defined processes in terms of both workflow and team interactions, has a clear connection to the work of Marks, Mathieu & Zaccaro (2001) regarding the role that established processes have with team effectiveness. Thus, the reason why the use of Scrum has been more effective in the software industry than other software methodologies (Rising & Janoff, 2000). A second key point is how the Scrum definition for leadership is more as a transversal enactment across team members (Schwaber & Sutherland, 2017), which is highly related to concepts of autonomy (Langfred, 2000). Scrum also emphasizes self-managing teams (Schwaber & Sutherland, 2017). However, Scrum as a framework is short in delimiting the extent of how to implement self-managing teams. Langfred (2000), for instance, presented a continuum where self-managing teams can be defined in terms of autonomy across the levels of individual autonomy within a team and team autonomy within an organization. This makes autonomy a key component when it comes to studying teams.

Both in teams, in general and in educational contexts specifically, autonomy plays a key role. It has been established before that high levels of individual and team autonomy have a high relationship with team effectiveness (Langfred, 2000). In addition, autonomy, at the individual level, is critical for promoting cooperation and learning (Johnson et al., 1998). On the other hand, there are some studies that presented mixed results promoting high levels of autonomy on both the individual and the team level (Guzzo & Dickson, 1996; Langfred, 2000). The main argument presented was that individuals with high levels of autonomy within a group with high levels of autonomy would cause disconnection between team members and slow down cooperation (Moe et al., 2010). Hence, the importance of leadership.

Leadership, as defined by Dickinson & McIntyre (1997), is the formal direction and instructions provided by established leadership, as well as the leadership enacted by other team members. They also highlighted that the enactment of leadership needs to cause a response among team members. In other words, the formal directions and instructions need to translate into concrete actions. This definition matches perfectly with the way Scrum promotes leadership inside a team. It makes sense to promote leadership with specific directions, given the fact that most software teams tend to be highly autonomous within an organization, and their team members have high levels of autonomy and decide how to better conduct their own work (Schwaber & Sutherland, 2017). These types of highly autonomous teams are often successful (Rising & Janoff, 2000; The Standish Group, 2015). It has been found that a well-defined leadership that promotes team orientation, membership, and goal-oriented attitudes, often serves as an effective moderator for individuals autonomy (Langfred, 2000; Salas, Sims, et al., 2005).

6.3 Team Performance

This subsection is centered in discussing in depth the information gathered from the regression models from the results chapter. Before starting the discussion on team performance, it is necessary to highlight the main differences in approaches that were followed during the both semesters analyzed in this study. There were no differences in terms of pedagogy, procedures, assignments or assessment. Nonetheless, during the Fall 2017 semester, the teams were left on their own, allowing themselves to define how to conduct their work under the Scrum framework. On the other

hand, during the Spring 2018 semester, immediately after the teams were formed, they received instructions on how teams had to operate under the Scrum framework, emphasizing on rotating roles so each student could experience being the Scrum master (i.e. leader). Moreover, part of the instructions highlighted that the teams were completely autonomous, and they would be responsible for monitoring their own performance and members' accountability. These instructions included the Scrum values and the expectations of a good team member. With such clarification, it is possible that some of the individual team characteristics played a more important role in the variability of team performance, more so when the teams were presented with clear instructions on how to perform as a team and the expectations to serve as a team member (i.e. Spring 2018 semester). Previous work has suggested that providing clear instructions to students can promote cooperative interactions between individuals because there are clear indications on how each team member success is linked to other team members' success (Johnson et al., 1998). In addition, putting in place mechanisms that assess individual accountability within the team will ensure that team members perform and learn together, and subsequently perform better as individuals (Johnson et al., 1998).

Providing clear instructions to the teams regarding individual and team expectations is a clear enactment of leadership (Dickinson & McIntyre, 1997) in the organization level. When clear levels of leadership are communicated at the organization level (or in a classroom context), those can be adopted by the teams. The teams in this study possibly enacted and promoted these clear levels of leadership within the team. Leadership serving as the moderator between the other team characteristics (Langfred, 2000; Salas, Sims, et al., 2005). This observation was supported by the individual variability of the team characteristics presented in the results chapter. It was also supported by the results from the regression models, where in most cases, leadership was the first team characteristic to be removed from the analysis through backward elimination. The latter can be interpreted as the higher the enactment of the coordination team characteristics (i.e. Monitoring, feedback and backup behavior), the less leadership enactment was displayed, supporting the importance on leadership presented in the section 6.1.

When analyzing the regression models directly, there was an interesting behavior regarding the team characteristics between the two semesters under this study. The Spring 2018 semester had a

clearer distinction regarding how team characteristics played an important role in the performance variability, while in the Fall 2017 semester, it did not yield such strong results. This could possibly be explained by the leadership and team expectations instructions provided to the teams during Spring 2018. The lack of team operation instructions to the teams during the Fall 2017 semester could have added intervening variables that could have not been accounted for in the regression models. These teams still needed to perform and achieved their goals but could have followed their own approaches and behaviors that might have not been accounted for under the conceptual framework used in this study.

On the other hand, all the regression models, included the ones constructed for the Fall 2017 semester, yielded an interesting pattern. The variability of the team performance during the Milestones could be explained in high percentage by the enactment of monitoring. Considering all the possible variables interacting with the multiple team processes, having a single team characteristic explain around the 20 to 30 percent of the performance variability is hard to overlook. Monitoring, in general, consisted of team members being competent on their individual tasks and having a proper understanding of the tasks of other members (Dickinson & McIntyre, 1997). This behavior might not often occur for every type of team composition, but it perfectly fits for software teams. Team members within a software team should have a proper understanding of all the parts of the project, and how these parts are divided among the team members. This is especially true in Scrum where team structures are horizontal and all team members have the same role with similar tasks (Schwaber & Sutherland, 2017). Furthermore, the way Scrum teams are structured embodies key components for promotive cooperation in educational contexts. Promotive interaction and group processing (Johnson et al., 1998) require team members to have a high level of awareness of each other's tasks in order to support and assist individual efforts. Likewise, there needs to be understanding of each team members' task in order to identify processes that need improvement.

A clear argument was made on highlighting leadership and monitoring as the key teamwork characteristics as the most impactful on the overall performance of teams during a semester-long project. Although the initial argument was made for the enactment of leadership and how this decreased the enactment or the need for other team characteristics, it was never said that other team characteristics were inexistent. Perhaps they were just less required when clear leadership

was set in place. When adequate leadership is set in place and teams are performing as expected, monitoring is the key ingredient that holds everything together. Monitoring keeps the individual accountability in place and the awareness between team members on how the team is performing. This awareness is key for leadership to be enacted among members in terms of promoting corrective actions (i.e. feedback) (Dickinson & McIntyre, 1997) and group processing (Johnson et al., 1998).

6.4 Implications for Teaching and Learning

This study encompassed the approaches followed by teams of students, following a software methodology that is widely used by professional teams. The adequacy of the analysis relied on the key characteristics for cooperative learning (Johnson et al., 1998) to occur, and how close these characteristics were to the team guidelines provided by Scrum (Layton, 2015; Schwaber & Sutherland, 2017). Considering that all the teams included in this study developed a satisfactory project without major difficulties, this study provided some key insight into the pieces that need to be put in place for teams to succeed in the classroom setting.

Understanding that the major difference between the two terms that were analyzed can provide some insight into how to operate as a team, as well as some insights about how to enact leadership, puts in perspective the level of detailed instruction the students may need receive in order to succeed in the classroom. Students needed clear goal setting and expectations to thrive in the classroom. Providing extra instructions on how students can achieve the previously set goals and expectations may promote better interactions between team members. Furthermore, making explicit the conditions that students should follow in order to cooperate successfully (Johnson et al., 1998), could guarantee that students will stick to these conditions and follow better processes to mediate teamwork (Langfred, 2000; Salas, Sims, et al., 2005). If the processes to mediate teamwork are provided within a known framework (e.g. Scrum), the teams most likely will follow it. The results of this study support these behaviors by making clear how providing clear instructions may affect the enactment of teamwork characteristics, and how the key enactment of these characteristics may affect the variability on performance.

CHAPTER 7. CONCLUSIONS, LIMITATIONS, AND FUTURE WORK

One limitation of this study was that no inter-rater reliability was considered during the measurement of the teamwork characteristics. This consideration was mitigated by the use of intra-rater reliability, along with other measures of validity and reliability in the selection and construction of the measurements. The detailed findings of this study, however, bring a new perspective into (1) how Scrum relates to cooperative learning, (2) how that combination relates to performance, and (3) how their implementation can be enacted in a systems analysis and design class. The study also provides deeper insights into specific team characteristics and venues for future work as follows.

In the discussion chapter, leadership and autonomy were identified as intertwined characteristics of teams. Autonomy was highlighted in this study in the context of software teams, but was never really measured or set as part of the team characteristics under this study. Given the different dimensions of autonomy that had been established (Langfred, 2000), it is worth considering for future work, how teams perform under different conditions of autonomy. These conditions could help determine under which levels of autonomy is leadership clearly a characteristic inherent to any type of teamwork, or if it is a characteristic that is strongly attached to certain types of teams.

In addition, getting a clear sense on how leadership is part of different types of teams would give a better understanding of how teams can really be studied in general terms, or needed to be put in the context of team composition and the medium on which they perform (Guzzo & Dickson, 1996). Moreover, this study raised the question of if it would be a better fit to analyze teams based on the processes and tasks that they need to perform. These analysis could be conducted by having a clearly established taxonomy for team processes and goals (Marks et al., 2001).

This study allowed to strongly connect different aspects of cooperative learning (Johnson et al., 1998) and Scrum (Schwaber & Sutherland, 2017). The interesting mediation that Scrum offered between leadership and autonomy were key in the classroom setting, which could point to interesting possibilities in introducing Scrum as a base framework to conduct teamwork in educational contexts regardless of the discipline. Scrum uses a clear way to define leadership

which reconciles the high levels of autonomy in both the team and the individual level, which are inherent to the classroom setting.

As highlighted in the discussion chapter, monitoring became a critical characteristic within the teams who followed Scrum closely. The ability of each individual to be aware of their own work as the overall team progressed and their contributions, not only is essential to the Scrum values (Schwaber & Sutherland, 2017) but fits perfectly into the key characteristics of cooperative learning (Johnson et al., 1998). Once more, providing great insight on how Scrum could be a good base framework for teamwork in classrooms.

In general, this study concludes that leadership and monitoring are key teamwork characteristics, specifically in the software context. Nonetheless, the main characteristic that was addressed was autonomy, which is not only an aspect to be considered in software teams but in any kind of teams. The purpose was to highlight Scrum as a tool to reconcile the different dimensions of autonomy within teams, by providing further understanding on how Scrum presents leadership in a very structured and procedural way. This leadership approach could be useful in many other fields and disciplines that fit into the same autonomy continuum.

Regarding the characteristics of students' self-reported teamwork experiences as part of a semester-long project, this study concludes that students in this systems analysis and design course enacted teamwork characteristics such as team orientation, team leadership, monitoring, feedback, backup behavior and coordination throughout their four milestones delivered during the semester. Regarding how these self-reported teamwork characteristics changed throughout the semester-long project, this study concludes that teamwork characteristics were not a static measure, and that the presence or enactment of these characteristics could have been affected by slight changes on the workload and circumstances of the team dynamics. Finally, regarding which of these self-reported teamwork characteristics were the most impactful on overall team performance during a semester-long project, this study concludes that the ability of team members to stay on top of their work and be aware of the overall progress of their own and other team members (i.e. Monitoring) had the biggest impact on the overall performance of the team. Furthermore,

leadership played a critical role on keeping monitoring in place within the team guaranteeing proper interactions and goals achievement.

APPENDIX

Appendix A: Description of Milestones (Magana et al., 2018)

Milestone	Deliverables
Milestone 1	• *Introduction:* Who are you and what is your requirement analysis strategy (BPA, BPI, BPR)? • *Project Vision Statement:* What do you want your end product to be? • *Context Diagram:* Inputs/Outputs to and from the system. • *System Request:* project sponsor, business need, business requirements, business value and special constraints. • *Product Roadmap:* a picture of your post-it notes listing and prioritizing requirements. • *Product backlog:* the master to-do list considering input from Product Roadmap. See hints for more info. • *Team Retrospective:* Evaluation of team performance during the milestone just finished and plan of action.

Milestone 2	• *Updated product backlog:* Created from the requirements from product roadmap.
	  ○ Make sure you include the estimation.
	• *Use-case Diagram:* A diagram that represents the interactions between actors and use cases, including the relations among use cases.
	• *Use-Case narratives:* Describe in detail each use case including the ideal course of event and at least one alternate course of event (more than one if needed).
	  ○ Each team member should build at least two use-case narratives
	• *Gantt chart:* Include the estimates for each sprint and milestones. It should be updated along the process and delivered for each milestone.
	• *Cash Flow*: Financial cost-benefit analysis.
	• *Team Retrospective*: Evaluation of the milestone just finished and plan of action.

Milestone 3	• *Updated product backlog:* Created from the requirements from product roadmap.
	• *Class diagram:* Identify the classes for your solution and the relationships among them. Build the class-diagram including attributes, relations and cardinality/multiplicity.
	• *Activity Diagrams:* Each team member should work on his or her two use case narratives. For each use case narrative, build the corresponding activity diagram.
	  o Each team member should build at least two activity diagrams
	• *Sequence Diagrams:* Each team member should work on his or her two use case narratives. For each use case narrative, build a sequence diagram for at least two of the scenarios in them.
	  o Each team member should build at least four sequence diagrams
	• *Updated Gantt Chart:* Include the estimates for each sprint. It should be updated along the process and delivered for each milestone.
	• *Team Retrospective:* Evaluation of the milestone just finished and plan of action

Milestone 4	• *One-Page Executive Summary:* highlights of the main points of the problem and main points of your proposed solution
	  o Start by describing the mission of the company and briefly describe the problem they have.
	  o Describe your solution. You may want to start by stating the project vision statement and then the system you are proposing. It would be a good idea to describe here your architecture design (web-based, cloud-based, software, hardware, etc.).
	  o Briefly describe how features of your system address the company's problem. (You can state them as a paragraph or as bullet points).
	  o Provide details about your estimated timeline to complete the system as well as the overall cost.
	  o Conclude by stating your competitive advantage.
	• *Updated product backlog:* Created from the requirements from product roadmap.
	• *Packages:* Group class diagram into packages.
	• *Entity Relationship Diagram:* Tables, relationships, cardinality. Should be normalized.
	• *Updated Gantt Chart:* Include the estimates for each sprint. It should be updated along the process and delivered for each milestone.
	• *Team Retrospective:* Evaluation of the milestone just finished and plan of action

Milestone 5	• *One-Page Executive Summary* (highlights of the main points of the problem and main points of your proposed solution)
	• *Table of Contents*
	• *All revised milestones* (M1 to M4) organized as follows:
	  ○ Introduction
	  ○ Project Vision Statement
	  ○ Context Diagram
	  ○ System Request
	  ○ Product Roadmap
	  ○ Updated Product backlog
	  ○ For each of the 10 use-cases integrate the following information:
	  ▪ *Use-Case narrative*
	  ▪ *Activity Diagram*
	  ▪ *Sequence Diagram*
	  ○ Class diagram
	  ○ Packages
	  ○ Entity Relationship diagram
	  ○ Updated Gantt chart
	  ○ Updated Cash Flow
	• *Deployment Diagram:* Describe the physical layer where your system will be installed and create a deployment diagram. Describe each component (e.g., servers, devices, etc.) providing the specifications of each of them and the communication protocols and type of network.
	• Screen shots of the final product (working software)
	• *Executable file or link of the final product* (include user name and password, if applies)
	• *Evidence of preliminary usability testing of the prototype:* add here your evaluation (also submitted separately)
	  ○ Discuss strengths and weaknesses of your prototype.
	• *Final Team Retrospective*

Appendix B: Milestone Rubrics

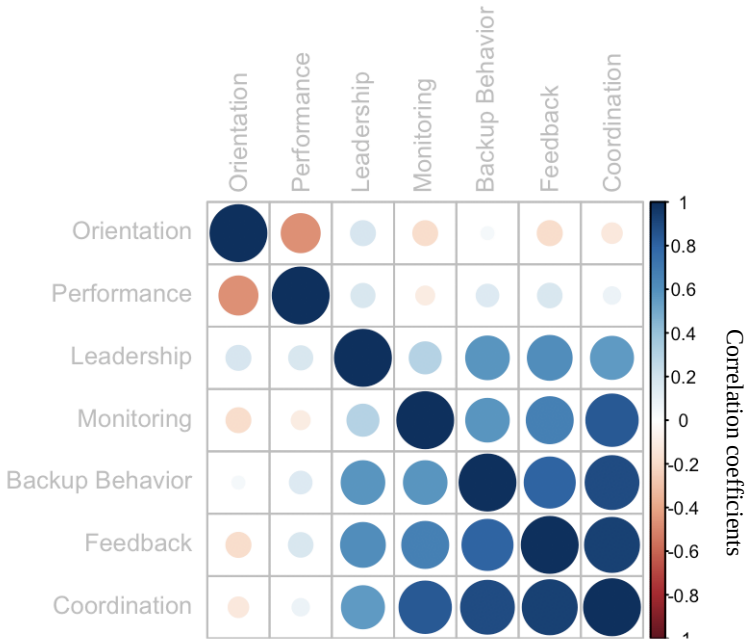
Milestone 1 Rubric			
	Novice	Competent	Proficient
Introduction and Project Vision Statement	0 (0.00%) - 0.3 (3.00%)	0.3 (3.00%) - 0.9 (9.00%)	0.9 (9.00%) - 1.5 (15.00%)
	Introduction and project vision were not provided.	Introduction or project vision were missing or were poorly written.	Introduction and project vision were complete and accurate.
Context Diagram	0 (0.00%) - 0.4 (4.00%)	0.4 (4.00%) - 1.2 (12.00%)	1.2 (12.00%) - 2 (20.00%)
	Context diagram was not provided or was incorrect.	Context diagram was somewhat complete or accurate.	Context diagram was complete and accurate. It included all actors and critical inputs and outputs of the system.
Systems Request	0 (0.00%) - 0.7 (7.00%)	0.7 (7.00%) - 2.1 (21.00%)	0.7 (7.00%) - 2.1 (21.00%)
	System request was missing or very incomplete	Systems request was provided but was somewhat incomplete or inaccurate.	Systems request was mostly complete and accurate.
Product Roadmap and Backlog	0 (0.00%) - 0.4 (4.00%)	0.4 (4.00%) - 1.2 (12.00%)	1.2 (12.00%) - 2 (20.00%)
	Product backlog was not provided or was very incomplete.	Product backlog was mostly accurate but critical requirements were missing.	Product backlog was accurate and listed most or all critical requirements.
Team Retrospective	0 (0.00%) - 0 (0.00%)	0 (0.00%) - 0.5 (5.00%)	0.5 (5.00%) - 1 (10.00%)
	Team retrospective was missing	Team retrospective was missing team's performance evaluation or plan of action.	Team retrospective included team's performance evaluation and plan of action.

Milestone 2 Rubric			
	Novice	Competent	Proficient
Project management (Gantt chart)	0 (0.00%) - 0.3 (2.00%)	0.3 (2.00%) - 0.9 (6.00%)	0.9 (6.00%) - 1.5 (10.00%)
	Minimally acceptable application of techniques for project management as evidenced by a not well maintained Gantt chart and incomplete product backlog.	Acceptable application of techniques for project management as evidenced by an acceptable Gantt chart and relatively complete product backlog.	Very Accurate and thorough application of techniques for project management as evidenced by well maintained Gantt chart and a very complete product backlog.
Feasibility analysis (cash flow)	0 (0.00%) - 0.45 (3.00%)	0.45 (3.00%) - 1.35 (9.00%)	1.35 (9.00%) - 2.25 (15.00%)
	Minimally acceptable identification of feasibility analysis evidenced by the incompleteness or lack of a cash flow.	Acceptable identification of feasibility analysis evidenced by somewhat presentation a cash flow.	Very accurate identification of feasibility analysis evidenced by an accurate presentation of a cash flow
Requirements determination (use-case narratives)	0 (0.00%) - 0.9 (6.00%)	0.9 (6.00%) - 2.7 (18.00%)	2.7 (18.00%) - 4.5 (30.00%)
	Minimally acceptable identification of system requirements evidenced by the incompleteness or lack of use case narratives.	Acceptable identification of system requirements evidenced by somewhat presentation of use case narratives.	Very accurate identification of system requirements evidenced by accurate presentation of most of the required use case narratives.
Team retrospective	0 (0.00%) - 0.3 (2.00%)	0.3 (2.00%) - 0.9 (6.00%)	0.9 (6.00%) - 1.5 (10.00%)
	Team retrospective was missing.	Team retrospective was missing team's performance evaluation or plan of action.	Team retrospective included team's performance evaluation and plan of action.

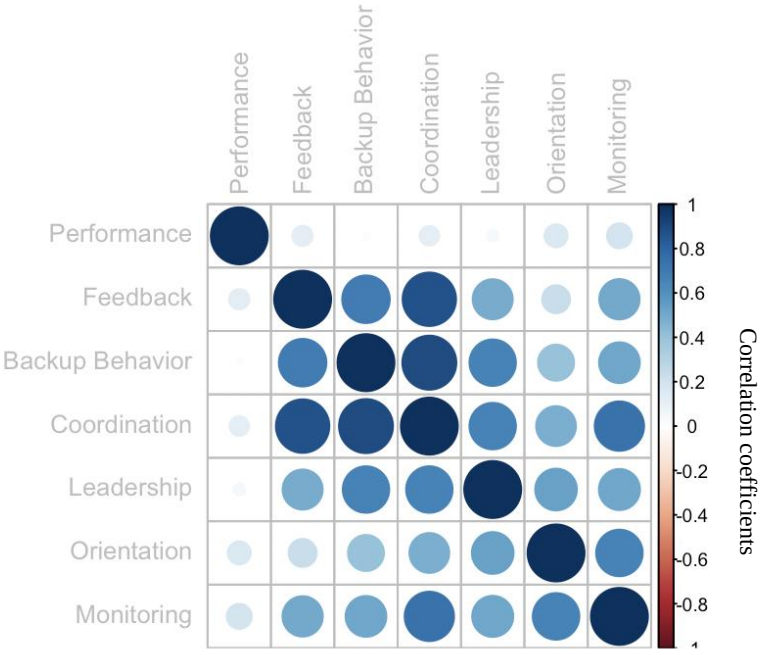
Requirements determination (product backlog)	0 (0.00%) - 0.6 (4.00%)	0.6 (4.00%) - 1.8 (12.00%)	1.8 (12.00%) - 3 (20.00%)
	Product backlog was missing or poorly presented.	Product backlog was provided but requirements were missing or the list was not prioritized.	Product backlog was properly presented listing requirements as user stories and the list was properly ordered by priority.
Requirements determination (use-case diagram)	0 (0.00%) - 0.45 (3.00%)	0.45 (3.00%) - 1.35 (9.00%)	1.35 (9.00%) - 2.25 (15.00%)
	Use case diagram was missing or poorly presented.	Use case diagram was provided but had some deficiencies or was somewhat inaccurate	Use case diagram included all corresponding actors and most of the use cases.

Milestone 3 Rubric			
	Novice	Competent	Proficient
Project management	0 (0.00%) - 0.4 (2.00%)	0.4 (2.00%) - 1.2 (6.00%)	1.2 (6.00%) - 2 (10.00%)
	Minimally acceptable application of techniques for project management as evidenced by a not well maintained Gantt chart and an incomplete product backlog.	Acceptable application of techniques for project management as evidenced by an acceptable Gantt chart and relatively complete product backlog.	Very accurate and thorough application of techniques for project management as evidenced by well maintained Gantt chart and a very complete product backlog.
Class diagram	0 (0.00%) - 0.8 (4.00%)	0.8 (4.00%) - 2.4 (12.00%)	2.4 (12.00%) - 4 (20.00%)
	The class diagram was incomplete or poorly presented.	The class diagram was complete but was somewhat inaccurate.	The class diagram was complete and mostly accurate.
Activity diagrams	0 (0.00%) - 1.2 (6.00%)	1.2 (6.00%) - 3.6 (18.00%)	3.6 (18.00%) - 6 (30.00%)
	About 1/3 of the required activity diagrams were provided and some of them were inaccurate.	More than half of the required activity diagrams were provided and most of them were accurate.	Most or all of the required activity diagrams were provided and the majority were accurate.
Sequence diagrams	0 (0.00%) - 1.4 (7.00%)	1.4 (7.00%) - 4.2 (21.00%)	4.2 (21.00%) - 7 (35.00%)
	About 1/3 of the required sequence diagrams were provided and some of them were inaccurate	More than half of the required sequence diagrams were provided and most of them were accurate	Most or all of the required sequence diagrams were provided and the majority were accurate.
Team retrospective	0 (0.00%) - 0.2 (1.00%)	0.2 (1.00%) - 0.6 (3.00%)	0.6 (3.00%) - 1 (5.00%)
	Team retrospective was missing.	Team retrospective was missing team's performance evaluation or plan of action.	Team retrospective included team's performance evaluation and plan of action

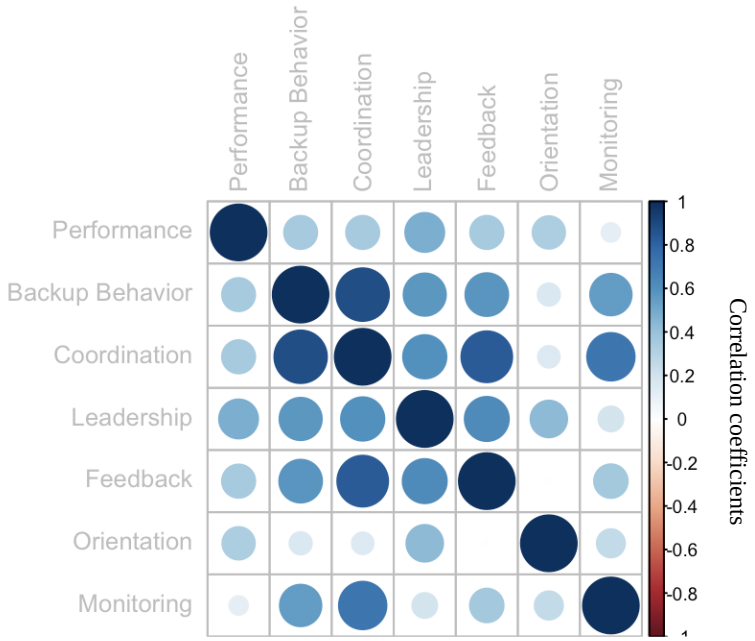
Milestone 4 Rubric			
	Novice	Competent	Proficient
Project management	0 (0.00%) - 0.6 (4.00%)	0.6 (4.00%) - 1.8 (12.00%)	1.8 (12.00%) - 3 (20.00%)
	Minimally acceptable application of techniques for project management as evidenced by a not well maintained Gantt chart and an incomplete product backlog.	Acceptable application of techniques for project management as evidenced by an acceptable Gantt chart and relatively complete product backlog.	Very accurate and thorough application of techniques for project management as evidenced by well maintained Gantt chart and a very complete product backlog.
Executive summary	0 (0.00%) - 0.75 (5.00%)	0.75 (5.00%) - 2.25 (15.00%)	2.25 (15.00%) - 3.75 (25.00%)
	The executive summary was missing or poorly prepared.	The executive summary was presented but was incomplete.	The executive summary was complete and well-presented.
Packages	0 (0.00%) - 0.75 (5.00%)	0.75 (5.00%) - 2.25 (15.00%)	2.25 (15.00%) - 3.75 (25.00%)
	Packages were missing.	Packages were somewhat illogical.	Packages were presented logically.
Entity-relationship diagram	0 (0.00%) - 0.75 (5.00%)	0.75 (5.00%) - 2.25 (15.00%)	2.25 (15.00%) - 3.75 (25.00%)
	ERD was missing or inaccurate.	The ERD was somewhat accurate and it was somewhat aligned with the class diagram.	The ERD was complete and accurate including all entities, attributes, relationships and cardinality. There was also an alignment with the class diagram.
Team retrospective	0 (0.00%) - 0.15 (1.00%)	0.15 (1.00%) - 0.45 (3.00%)	0.45 (3.00%) - 0.75 (5.00%)
	Team retrospective was missing.	Team retrospective was missing team's performance evaluation or plan of action.	Team retrospective included team's performance evaluation and plan of action.



Appendix C: Fall 2017 Milestone 1 Correlation

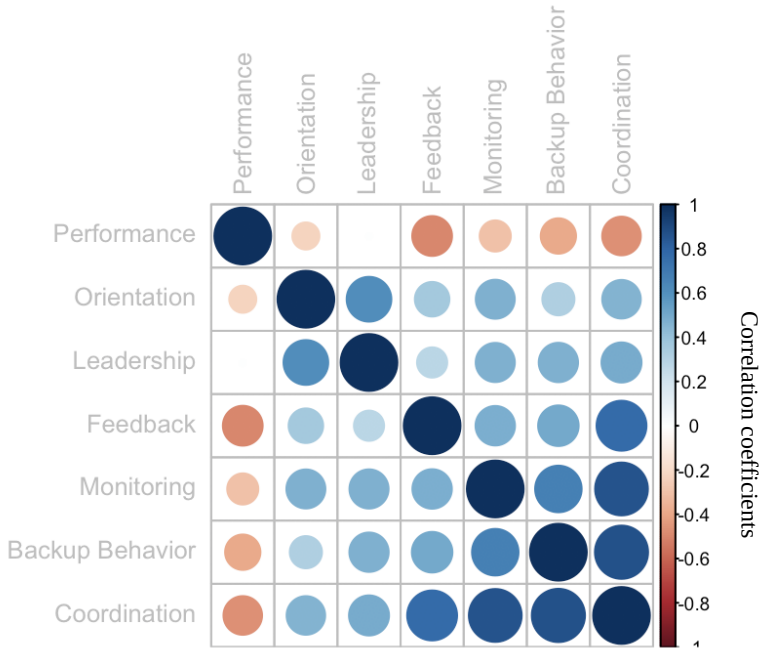


Appendix D: Fall 2017 Milestone 2 Correlation

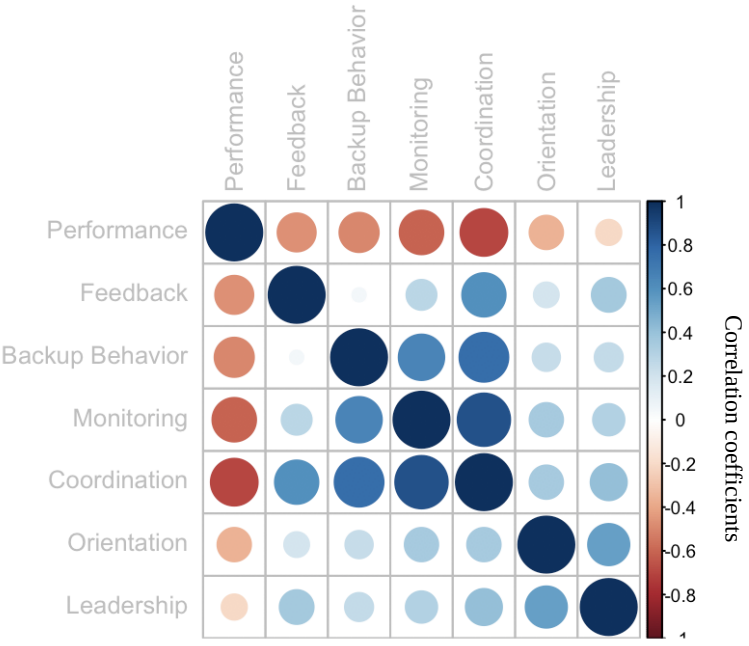


Appendix E: Fall 2017 Milestone 3 Correlation

Appendix F: Spring 2018 Milestone 1 Correlation



Appendix G: Spring 2018 Milestone 2 Correlation



Appendix H: Spring 2018 Milestone 3 Correlation

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