UNDERSTANDING ENGINEERING EDUCATION IN DISPLACEMENT: A QUALITATIVE STUDY OF "*LOCALIZED ENGINEERING*" IN TWO REFUGEE CAMPS

by

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For my mother and son, Ilca and Leonardo.

This dissertation is dedicated to all my former students in Jordan and Kenya.

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ABSTRACT

The duration of exile in refugee communities has grown immensely over the last two decades. Recent humanitarian reports have called for actors to create more coordinated global support for the refugee crises. In these recent calls, the desire to break a cycle of dependency between the refugee community and international aid has been a clear priority. Hence, education has emerged as a strategic action to foster refugee self-reliance, particularly higher education (HE) and technical and vocational education and training (TVET). There are many opportunities to use HE and TVET to benefit the refugee community, including: developing solutions to improve living conditions, enabling new opportunities for learning pathways, allowing refugees to contribute to the economy in hosting countries, or preparing them to rebuild their lives once they return to their home countries. However, the economic, political, and cultural complexities of refugee communities often add layers of challenges to typical formal HE and TVET programs. In addition, the existing literature in refugee education still lacks a coherent analysis of these factors and conditions for adoption of HE and TVET programs, especially for refugees living in camps.

To address these gaps, this dissertation presents three studies that investigate an undergraduate introductory engineering course for refugees called Localized Engineering in Displacement (LED). Specifically, I draw on effective learning and policy frameworks to understand how to situate engineering education across HE and TVET and advance LED in refugee camps. The first study presents a case study examining the iterative processes of creation and implementation of the LED course in the Azraq refugee camp in Jordan. As a general outcome of my study, I describe the novel approach to teaching engineering design for learners in the Azraq refugee camp and its applications to other contexts. The second study examines the LED course implemented in the Kakuma refugee camp. The Kakuma refugee camp is situated in Kenya and considered the largest refugee camp in the world, thus providing a different context of refugee camps. I discuss the contextual challenges to transfer, develop, and implement to a new context and present the course outcomes and experiences based on the course participants' reflections. The third study extends findings from the first and second studies by using a comparative case study to critically examine the development process and challenges of

engineering education in refugee camps. Central to my analysis is the connection between the challenges identified in both camps and existing actors involved with refugee education.

My research uses two case studies to underscore the complexity of the LED course development in the Azraq and Kakuma camps. I seek to foster a debate about the challenges that influence the development of higher engineering education programs in refugee camps and how different actors can collaborate to advance high-quality engineering education initiatives in refugee contexts. Overall, this dissertation clarifies some of the biggest challenges to implement engineering education in refugee settings, how different actors can collaborate to mitigate these challenges, and how these findings expose the misalignment between the international rhetoric and reality on the ground in refugee camps.

1. DISSERTATION OVERVIEW

1.1 Introduction

As refugees are kept in exile for more than two decades (UNHCR, 2016a), their quality of life, including the quality of their education, becomes a crucial factor for their ability to become members of the community. In light of this long term reality, it has been argued that traditional types of external and temporary aid, such as food and medical assistance, have become less significant in refugees' lives (Easton-Calabria & Omata, 2018). Self-reliance has become a fundamental strategy to develop durable solutions to mitigate the refugee crises and reducing external aid dependency (Aleinikoff, 2015; UNHCR, 2005).

However, while increasing efforts to promote refugee self-reliance dominate the policy arena, recent studies indicate a significant gap between the international discourse and realistic conditions to achieve this goal (Easton-Calabria & Omata, 2018). This gap also yields non-realistic decisions that can overlook important priorities to support the refugee community, such as the resources allocated for refugee education or even appropriate pedagogy for learners in displacement. Platzer (2018) points out that neither the United Nations nor member states provide the necessary economic and political resources to foster access to tertiary education for refugees. In light of this lack of support, how can refugee stakeholders discuss education as a tool to promote refugee self-reliance when refugees still lack access to educational opportunities?

The United Nations High Commissioner for Refugees (UNHCR) estimates that only 3% of adult refugee learners who are eligible for postsecondary education are able to enroll in higher education programs (UNHCR, 2019g). Building upon and contributing to the global efforts to foster refugee self-reliance (Aleinikoff, 2015; Clements, Shoffner, & Zamore, 2016; Easton-Calabria & Omata, 2018; Ilcan, Oliver, & Connoy, 2017; Ilcan, 2018; UNHCR, 2018b), this dissertation focuses on analyzing the challenges and opportunities to develop an engineering education program to foster self-reliance in two refugee camps.

To address these opportunities and to make sure that humanitarian settings also benefit from engineering education, many scholars have provided frameworks to inform the connection of engineering education and humanitarian development. For instance, some models of engineering education and humanitarian development are service-learning (Berg, Lee, &

Buchanan, 2016; Bischel & Sundstrom, 2011; Gan, 2018; Goffnett, Keith Helferich, & Buschlen, 2013) and humanitarian engineering (Amadei & Wallace, 2009; Mazzurco & Jesiek, 2017; Mitcham & Munoz, 2010; Schneider, Leydens, & Lucena, 2008). Hence, discussing humanitarian aspects in education is crucial because engineering provides opportunities to improve the living conditions of refugee settings, particularly those in refugee camps. Yet while new humanitarian engineering programs are typically implemented in the humanitarian contexts, engineering expertise is often brought in from outside the refugee community. These decontextualized approaches yield results that primarily have an immediate impact with questionable outcomes sometimes and this structure grounded in external aid reinforces a cycle of dependency.

Recognizing the complex political and social nature of education in refugee settings, there are two important facets of refugee education that inform this dissertation. The first facet relates to the pedagogical strategies used throughout the course creation and implementation to foster effective learning for the refugees. The second facet relies upon the political factors that underline contextual challenges, the role of different actors to overcome these challenges, and the conditions to foster self-reliance in refugee camps through engineering education. Hence, this three-paper dissertation uses qualitative methods to investigate the following research goal: W*hat is necessary for the adoption and utility of engineering education as a tool to meet international goals of fostering self-reliance in refugee communities?* Together, these papers provide a thorough investigation of the challenges and opportunities to develop an introductory engineering course for refugees that utilizes a learning environment called *Localized Engineering* in Displacement (LED).

1.1.1 What is Localized Engineering in Displacement?

Launched in 2016, the LED emerged as a higher education response to provide high-quality undergraduate education for refugees by focusing on engineering design and community development. The localized engineering model fosters students' agency to create solutions for themselves and co-create course directions based on students' guidance (DeBoer, Radhakrishnan, & Freitas, under review). To build on learners' assets, the LED engineering curriculum examines the boundaries of the local community and the problems they are obligated to solve. In the refugee context, it is challenging to identify what the 'local' includes, given the

dynamic and contextual political and social scenario that change across camps. Instructors and students must navigate this by iteratively and collectively defining the different actors and their cross-collaboration within their local community. Thus, *localized engineering* emerged as a term to describe a pedagogical curriculum focused on advancing praxis in alignment with local standards and contextual challenges in displacement contexts, such as refugee camps.

Localized Engineering incorporates aspects of active, blended, collaborative, and democratic (ABCD) learning. Active learning refers to engaging in hands-on activities where students learn by going beyond passively receiving information (Freeman et al., 2014). Blended learning incorporates a mix of online resources, printed materials, and face-to-face interactions to allow flexibility to students' needs and infrastructure limitations (Garrison & Vaughan, 2007). Through collaborative learning, students co-design and co-construct knowledge with their peers (Rutherford, 2014). Democratic learning, which is grounded in critical pedagogy (Freire, 1970; Wylie, 2014), positions teachers and students to exercise their roles as critical agents of change in society. LED creates a curriculum that enables learners to acquire technical, professional, and design engineering skills by incorporating ABCD learning. The course curriculum also overlaps with the skillsets of entrepreneurship by providing support for further development of the engineering solutions created in the course. The LED course uses engineering design as an approach to solve real-world problems and covers the main elements of authentic problem solving in a dynamic and friendly environment.

1.1.2 Description of the Course

Learning outcomes and assessment

The overall goal of this course was to prepare students to solve problems using engineering design effectively. Thus, the LED course targeted the following learning objectives:

1. Using a systematic problem-solving method to identify, evaluate, and scope an engineering problem.
2. Applying engineering design process to generate ideas, critically evaluate and develop evidence-based solutions.
3. Fostering the growth of reflective individuals and empower their social agency.
4. Discussing and practicing professional competencies.

Engineering design process

Content coverage specific to the engineering design process (EDP) concepts comprised eight lessons spread across the whole span of the course, culminating in a final design prototype presented at the end of the course. EDP, as taught in this course, covered the following elements: need finding, problem identification and scoping, concept reduction and selection, evaluation, testing, prototyping, and communication. In addition, a professional engineer came to class and discussed engineering design and problem-solving in his daily work as an engineer in the camp. The guiding learning principles of design education served to prepare students to:

1. Represent and communicate their walk through the engineering design process in a final design project.
2. Demonstrate the ability to differentiate needs, problems, and solutions as essential components of the engineering design process.
3. Develop professional engineering skills, such as written and oral communication, decision-making, project planning, teamwork, negotiation, leadership, and dealing with stress.

Electrical and electronic systems

The electronics module included theoretical and hands-on activities in every class session. The entire electrical engineering and electronics module had eight class sessions. The overall course relied on practical application and project-based activities, so these activities prepared students to apply what they learned in their final design project. The electronics module was designed to prepare students to:

1. Conduct measurements and testing of the value of electrical variables.
2. Display and interpret data in graphs (e.g., analyze the relationship between variables on a graph, describe patterns between variables in a graph).
3. Identify and use engineering tools (e.g., multimeter, breadboard, soldering iron, calculator, hand tools) to build circuits.
4. Demonstrate electronic skills related to principles of electricity (conductors, insulators, Ohm's law, interpreting electrical symbols, measuring electrical component capacity, series and parallel circuits, voltage dividers).

Programming

The objective of this module was to provide basic programming skills so that students could create and modify the Arduino software depending on the type of sensor used in their specific circuit. This module comprised three class sessions where students learned how to open, modify, and debug codes, and add libraries from specific sensors or electronic modules. The entire programming module was integrated into the electronic session so that students could practice coding skills in different class sessions. The research team planned the programming content in order to prepare students to:

1. Develop logical thinking to program in C and design Arduino circuits.
2. Comprehend and manipulate software tools to program (e.g., Dev-C/C++ and Arduino IDE) in C and create reports.
3. Demonstrate mathematical literacy in the computing domain and basic procedural coding (if – then statements, equal to, greater than, less than, while, loop).

Solar energy

A two-lesson module was included in the course to provide a foundational understanding of solar energy principles as an authentic design problem context. Solar energy is commonly used in the Azraq camp due to the location in the desert, and students showed interest in comprehending and using this technology in the course. The instructors offered basic training related to electrical principles of solar energy and potential applications of solar cells in their design projects. This module was crafted in order to prepare students to:

1. Design and conduct experiments using solar photovoltaic (PV) energy.
2. Demonstrate basic knowledge about principles of sciences, such as thermodynamics, heat transfer, the transformation of electricity, the law of conservation of mass, force, and energy, density, and scientific notation.

1.1.3 Purpose of the Dissertation

The overall purpose of this dissertation is to present a pedagogical approach to TVET and HE developed in refugee camps and to explore the contextual challenges experienced throughout this development process. My motivation for investigating multiple facets of the course (both the pedagogical and political) is to propose a model that is aligned with education in displacement

and the current scenario proposed by international refugee frameworks in relation to the reality on the ground in refugee camps in Kenya and Jordan.

My findings from studying engineering education in refugee camps can translate to other research fields with marginalized and underserved communities. For example, I noticed similarities between the factors that influence effective learning across these settings, such as a motivation, psychosocial factors, and socio-cultural behaviors. I also noticed an interesting influence of multiple actors that lead to decisions that affect the course creation and implementation. As I was conducting the research studies, I also found promising pedagogical considerations about humanitarian engineering that could be developed in displaced contexts. This consideration of humanitarian engineering is also presented as one of the contributions of this dissertation.

Overall, my dissertation investigates the challenges that influence the development of engineering education programs in refugee settings and how different actors can respond to these challenges. My research will underline: (a) engineering education in refugee settings; (b) recommendations to provide the resources necessary for HE and TVET in refugee camps; and (c) the misalignment between international and national regulations along with the reality on the ground.

1.2 Literature Review and Analytical Framework

Here, I present the literature review and analytical framework that structures this exploratory case study by integrating important definitions, frameworks, and concepts. I start by outlining the relationships between this dissertation and the refugee crisis. Next, I examine the right to education for refugees and international policies that will underline the data analysis in my study. Then, I examine the connections between engineering education, higher education, and vocational training in displacement. After that, I focus on the role of engineering to foster community development. Finally, considering that social justice driven by democratic learning underlines the LED curriculum, I examine the integration of social justice into education by examining social justice in higher education and engineering education. I present the relationship between these components in Figure 1.

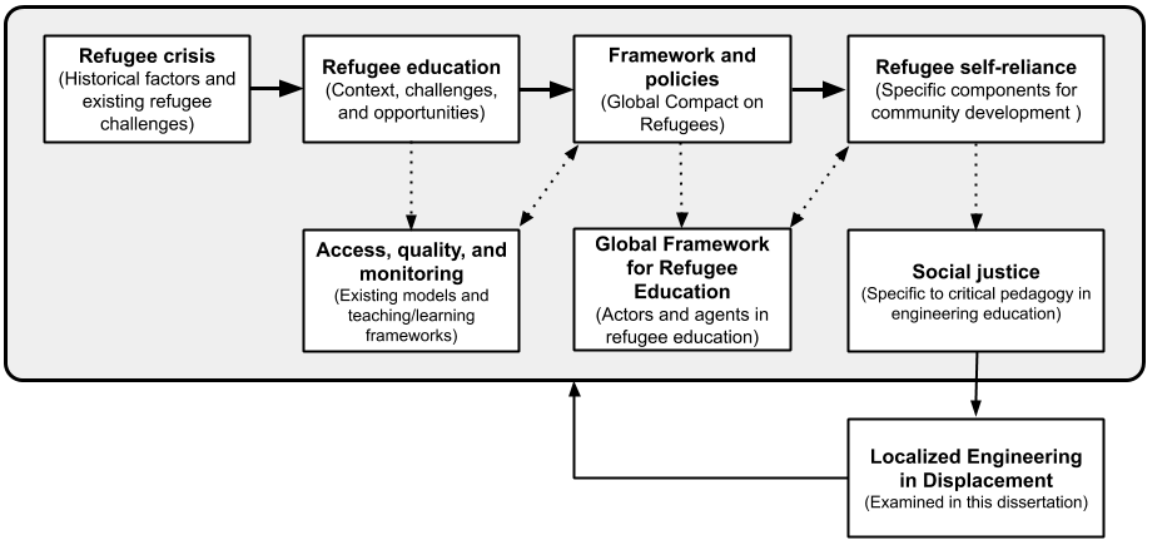


Figure 1. Components' relationship within the analytical framework and literature review

1.2.1 Understanding the refugee context

By the end of 2019, the displaced populations reached 70.8 million, with 25.9 million of these individuals being considered refugees (UNHCR, 2019a). A refugee, according to the refugee convention (UNCHR, 1951), is "someone unable or unwilling to return to their country of origin owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group, or political opinion" (p.3). Historically, the refugee crisis and status of refugees has roots in the period of World War II when several actions were taken to ensure the protection of people persecuted and serving as a precursor to what is known as a human right (Gibney & Loescher, 2010).

Today, the average length of displacement is approximately 20 years (UNHCR, 2016a). Considering that learners might spend their entire learning pathway throughout primary, secondary, and tertiary education as refugees, developing strategies to ensure access to high-quality education in formal and non-formal settings is more important than ever. On the other hand, while the provision of educational opportunities has been historically discussed as one of the strategies to address humanitarian crises, "not until the 1990s was education recognized as important enough to be undertaken concurrently with humanitarian relief" (Richardson, MacEwen, & Naylor, 2018, p.15). Hence, discussing and understanding refugee education and its role in the refugee crisis is more important than ever.

1.2.2 Understanding education in refugee crisis and working groups

Often, within the refugee context, terms like “refugee education” and “education in emergencies” are prevalent in humanitarian reports within a context of emergency or temporary solution, which leads may lead to a wrong perception in terms of quality and impact of education in displacement. It is appropriate to adopt terminologies while cognizant of its appropriate definition. In this dissertation, I call attention to two aspects of refugee education taken as a significant meaning throughout my study. First, I adopted terms like “refugee education”, “education for refugees”, and “education in displacement” as terminologies referring to the educational model developed for learners in refugee camps. Second, while humanitarian reports revealed that refugees received poor-quality education in many countries (Dryden-Peterson, 2011; UNHCR, 2018c), I discuss in this dissertation a pedagogical model for displacement while adopting high-quality standards throughout the process to design and develop the program. It is part of my research goal to describe this process in this dissertation.

With respect of education in refugee crisis, education points out for local development in situations where the context of crises can occur for many years, such as refugee camps. Dryden-Peterson (2011) argued that education does promote growth and development in refugee settings (Dryden-Peterson, 2011). What is often challenging in education for refugees, however, are the other dimensions of human crises, such as psychosocial support (PSS) and social and emotional learning (PSEL). Additionally, the complex and unique nature of displaced communities negatively affects the international efforts to meet specific goals for education in displacement (Demirdjian, 2011). Thus, global initiatives have been emerging to coordinate and support education initiatives in displacement. For example, the Connected Learning in Crisis Consortium (CLLC) is one example of a humanitarian network that aims to promote practical impact through higher education in crisis. The Inter-Agency Network for Education in Emergencies (INEE) is another example of a humanitarian network that seeks to promote access to quality, safe, and relevant education for the population in crisis through minimum standards to ensure high-quality education. These organizations are two examples of education initiatives developed to coordinate efforts to address education in the refugee crisis across different actors.

In general, humanitarian organizations have recognized that advocating for the inclusion of PSS and PSEL in the curricula is essential to enhance education in these contexts. For example, displaced learners often experience events and traumas that affect their mental health,

and continuous exposure to psychosocial, emotional traumas can lead to lifelong impairment of learning health (Shonkoff, Boyce, & McEwen, 2009). Thus, understanding the cognitive ability of students in learning disciplines like second language learning (Schoonen et al., 2003) and technological activity (Johnson, 1992) and how it interplays with emotional and physical overload is fundamental to enhance the learning experience.

Therefore, a number of recommendations to educators and professionals working in crisis have been emerging in order to address the specific needs in displacement. For example, the INEE Guidance Note on Psychosocial Support (INEE, 2018) offers a comprehensive document that is useful to government entities, policy-makers, community groups, humanitarian workers, parents, peers, and other education coordination and working groups. Another example of an education tool consists of a resource pack that would guide staff for putting together the resources for different actors. Through this pack, educators can address common challenges in emergencies, such as: emergency preparedness, assessment, staffing, supplies, safe spaces, teacher training, learning content, psychosocial support, and monitoring and evaluation (Nicolai, 2009).

Education is considered a critical element in the global actions to the refugee crisis (Hilal, 2019; UNHCR, 2019e; Williams, 2018) and it requires a collective engagement with multiple disciplines, stakeholders, government bodies, and non-governmental organizations. Education provides resources that are important specifically to displaced people including psychosocial support, development of conflict resolution, and preparation for reconstruction (Sinclair, 2002). However, education also gets disrupted in refugee situations, and displaced communities do not have guaranteed means to provide access to educational opportunities in refugee settings without humanitarian assistance (Demirdjian, 2011, p.6).

Since 2000, the field of refugee education has been associated with the broader field of education in emergencies (Dryden-Peterson, 2011, p. 19). On the other hand, the use of the term “emergency” does not necessarily connect to the importance of considering the long-term impact of displacement that might require actions to support post-conflict rehabilitation and reconstruction (Sinclair, 2002). Refugee camps are typically understood and described as places of temporary asylum (Turner, 2016). This misunderstanding results in a limited allocation of resources to education in these settings and inadequate policies to sustain learning pathways or even financial resources to invest in educational infrastructure. Considering that the current

length of displacement is nearly two decades (UNHCR, 2016a), refugee education needs to be considered as a long-term endeavor, connected not only to the idea of return but to the on-going nature of exile (Dryden-Peterson, 2017, p.15). Therefore, it is important to reflect this concern on existing policies and frameworks for refugees.

1.2.3 The right to education for refugees: frameworks and policies

Given the importance of treating education as a key element to address humanitarian crises, several international treaties have discussed and proposed actions to protect quality education in displacement. For example, the 1951 Refugee Convention is the oldest international treaty to stipulate the rights of refugees, including the duty of a host government to provide basic education. Subsequently, the International Covenant on Economic, Social, and Cultural Rights was published in 1966 to point out rights related to basic, secondary, and higher education. Similarly, the United Nations Convention on the Rights of the Child in 1989 also recognized the right of education.

The most recent international movement to discuss the refugee crisis within the policy arena is known as the New York Declaration for Refugees and Migrants, launched in September 2016. The New York Declaration opened a new space to engage the international community in elements of crisis that directly affect hosting countries and education initiatives in crises (e.g., psychosocial development, economic integration, safe learning environment, and skills and vocational education). The New York declaration also played an important role by offering conditions for subsequent actions to achieve specific education-related goals it laid out. For example, in December 2018, UN member states, international organizations, refugees, civil society, private sector, and other experts developed the Global Compact on Refugees (GCR) (UNHCR, 2018b).

The GCR emerged as an effective framework to translate the commitment to responsibility-sharing into practical actions. The objectives of the GCR are: (1) ease the pressures on host countries; (2) enhance refugee self-reliance; (3) expand access to third-country solutions' and (4) support conditions in countries of origin for return in safety and dignity. Not surprisingly, the refugee crisis is presented as a humanitarian problem that requires engaging different international and national actors, and therefore, the actions presented in the compact needed to connect all actors.

1.2.4 Understanding the GCR and Global Framework for Refugee Education

The next paragraphs draw on two documents, the Global Compact on Refugees and the Global Framework for Refugee Education (GFRE). The GCR and GFRE examine education as a key component in this political arena. The GCR emphasizes the partnership and participatory approach with refugees and host communities as part of an effective plan to address this humanitarian crisis. The GCR is a document that describes a wide range of strategies in the refugee context, and the education committee is mainly discussed as follows.

> 68. *In line with national education laws, policies, and planning, and in support of host countries, States and relevant stakeholders will contribute resources and expertise to expand and enhance the quality and inclusiveness of national education systems to facilitate access by refugee and host community children (both boys and girls), adolescents and youth to primary, secondary and tertiary education. More direct financial support and special efforts will be mobilized to minimize the time refugee boys and girls spend out of education, ideally a maximum of three months after arrival.*
>
> Source: Global Compact on Refugees, p. 13, paragraphs 68-69.

> 69. *Depending on the context, additional support could be contributed to expand educational facilities (including for early childhood development, and technical or vocational training) and teaching capacities (including support for, as appropriate, refugees and members of host communities who are or could be engaged as teachers, in line with national laws and policies). Additional areas for support include efforts to meet the specific education needs of refugees (including through "safe schools" and innovative methods such as online education) and overcome obstacles to their enrolment and attendance, including through flexible certified learning programmes, especially for girls, as well persons with disabilities and psychosocial trauma. Support will be provided for the development and implementation of national education sector plans that include refugees. Support will also be provided where needed to facilitate recognition of equivalency of academic, professional and vocational qualifications. (See also section 3.3, complementary pathways for admission to third countries).*
> 71. […] *and strengthening of these skills and qualifications through specific training programmes, including language and vocational training, linked to market opportunities, in particular for women, persons with disabilities, and youth.*
> 75. […] *Measures to strengthen the agency of women and girls, to promote women's economic empowerment and to support access by women and girls to education (including secondary and tertiary education) will be fostered.*
>
> Source: Global Compact on Refugees, p. 13-14, paragraphs 68-69; 71; 75.

The GCR and GFRE are used as baselines in my analysis because they represent the most recent, historical, and comprehensive plan of action to address the refugee crisis. In addition, the GCR provides a framework to understand the importance of engaging various actors from an

international perspective. The GFRE is important because it synthesizes the actors involved with refugee education. The GFRE framework also outlines calls to action related to higher education and TVET in refugee settings and helps understand how different actors are responsible for supporting refugee education from an international perspective. I discuss in more detail the GCR and GFRE in the next paragraphs.

The focus of the GCR is to enable a sharing of responsibility to respond to the refugee crisis in order to benefit both refugees and the host community. However, the guidelines presented overall actions that still required a more inclusive engagement among stakeholders. Therefore, in December of 2019, the Global Framework for Refugee Education (GFRE) (UNHCR, 2019c) was created to enable conditions to meet the commitments with the education of the Global Compact on Refugees by supporting conditions, partnerships, collaboration around, and approaches for refugee inclusion. The document targeted pre-primary, primary, secondary, and tertiary education and vocational education and training (TVET).

The GFRE offers a framework for actors involved with refugee education to mobilize and contribute to the refugee crisis by presenting six calls to action: (1) increase funding and national capacity; (2) strengthen programming and planning; (3) support and train teachers; (4) improve data for better investment; (5) strengthen partnership and coordination; and (6) engage and account for refugees and host communities. In order to achieve these goals, the document describes three outcome areas that require multiple collaborations, such as:

1. **Inclusion in national education systems:** Including refugee children and youth in national education systems to benefit from increased access to the full cycle of quality education, including ECDE, primary and secondary, as well as certified non-formal education.
2. **Qualifications and skills for work:** Increasing access to accredited TVET and higher education and eliminating systemic policy barriers.
3. **Emergency Response:** Providing timely and amplified education responses in emergencies that strengthen local education systems and support hosting communities to facilitate sustainable refugee inclusion.

The GFRE also points out four cross-cutting areas considered important to interconnect the three outcome areas listed in the previous paragraph. These four areas are: (1) policy and planning; (2) financing and resources; (3) equity and inclusion; and (4) innovation and connected

education. Additionally, several stakeholders are listed as fundamental to respond to the calls to action in the document. Considered the most recent outcome from international engagement to support refugees worldwide, the GFRE offers a unique framework to situate my work within an existing discussion about HE and TVET for refugees.

1.2.5 Relating GFRE to TVET and Higher Education for Refugees

In this section, I synthesize how HE and TVET are considered in the policy arena through the GFRE lenses. The GFRE suggests pledges that interconnect necessary actions and resources to specific actors in TVET (see Appendix A) and HE (see Appendix B). My goal in this dissertation is to describe the different perceptions of HE and TVET in the existing discourse towards refugee self-reliance. Subsequently, I discuss to what extent the *localized engineering* connects to these two education systems for refugees.

GFRE: TVET for refugees

The GFRE defines TVET as a key strategy to develop formal qualifications and skills for development relating to a wide range of occupational fields in agriculture, industry, or services. Additionally, TVET is presented as a fundamental component to support young people who are considering entrepreneurship or self-employment. According to the GFRE, the overall calls to action addressed to TVET are:

1. Increase investment in refugee access to TVET programs through the expansion of scholarships, fair and public national loan schemes, and standardized equitable tuition fees.
2. Ensure that the TVET programs are aligned to national development plans to generate an opportunity to bring together investments from development partners in coordination with education and labor market stakeholders.
3. Ensure women and persons with different needs can enroll in all fields of study and are not limited to particular areas of study. TVET curricula should be gender-responsive and should promote inclusion, diversity, and social cohesion. TVET campuses should be safe places to learn and students should have access to health care and counseling as part of their study program.

Technical and vocational training for refugee learners

TVET enables economic development, social development, and reduces marginalization (Hilal, 2019). The UNHCR recognized TVET as a specific area of training and skills development taken as part of a lifelong learning process that might occur at secondary, post-secondary, and tertiary levels (UNHCR, 2019d). Additionally, the UNHCR points out that TVET should incorporate aspects of inclusion, market orientation, support services, accreditation, teacher training, life skills, technology, and bridge to the labor market for refugees. TVET is explored in the literature as a form of education that can be used to foster community integration (Paulson, 2009), reduce inequalities (Hilal, 2017), and provide workplace-relevant training (Roche, 2017).

In the context of refugee education, TVET has been seen as an important step towards refugee self-reliance by providing means to ensure their integration in the economy. Hilal (2012) found that vocational training supports women and youth empowerment, and TVET "can play an enabling role of supporting marginalized groups" (p.64) by linking vocational training to human well-being. However, Duong and Morgan (2001) noted that while vocational training can support a displaced community, they also draw attention to the role of political and economic factors that play a role to effectively integrate refugee communities.

More than simply enhancing the quality of TVET programs, the International Labor Office (ILO, 2018) points out several main challenges that require attention towards TVET in displacement. These challenges include accessing TVET programs and decent jobs, lack of information, lacking recognition of qualifications and skills, and low collaboration between employers and workers' organizations. TVET is definitely considered an important component to encourage the development of both the refugee populations and economies (Williams, 2018), but it is important to allocate sufficient economic and political resources to take most of the potential from TVET to address immediate needs from displaced populations.

GFRE: Higher Education for refugees

The GFRE presents higher education as an opportunity to build on the competencies and skills acquired in upper secondary education that support learning at a higher level of complexity

and specialization. According to the GFRE, the overall calls to action addressed to higher education for refugees are:

1. Strengthen emphasis on the transition from secondary to tertiary education, including all types of post-secondary learning opportunities. This may include language, information and communication technology, and other skills training, catch-up or bridging courses and market-based career advising and counseling services. Support specific interventions to ensure that girls and persons with different needs transition successfully from secondary to tertiary and from tertiary to work.
2. Strengthen systems for efficient and cost-effective recognition of qualifications and prior learning. Ratify the Convention on the Recognition of Qualifications concerning Higher Education.
3. Increase funding for scholarship programs for refugees and vulnerable host community youth. Make national funding opportunities open for refugee students. Allow refugees to access education pathways under the same conditions as national students.

The GFRE also suggests pledges that interconnect necessary actions and resources to specific actors. Similar to what has been discussed in the previous section, each actor involved with HE has a different responsibility to offer conditions to enable HE for refugees.

Higher education for refugee learners

As Williams (2018) points out, "educating adults will yield a double advantage because it will benefit the individual livelihoods of those individuals as well as the future of the children and young people who depend upon them" (p.6). Additionally, providing higher education to the young populations can lead to durable solutions in crises (Wright & Plasterer, 2010). Higher education is strategically important to address the refugee crisis as the opportunities for refugees are minimal and often limited by policies and opportunities. For example, young refugees are often shut out of formal pathways to learning due to the lack of resources and opportunities for refugees. Of the adult refugee learners who are eligible for postsecondary education, the UNHCR estimates that only 3% are able to enroll in higher education programs (UNHCR, 2019), and the demand for higher education degrees, connected education, and vocational training have been increasing.

Several obstacles and barriers to students pursuing higher education relate to accreditation, language, and cost (Gladwell, Hollow, Robinson, Norman, Bowerman, Mitchell, Floremont, et al., 2016). Recent findings indicate that neither the United Nations or member states provide the necessary resources for higher education for refugees (Platzer, 2018, p. 192). In light of these gaps, there is an emerging body of literature describing strategies to offer accessible and quality education for refugees. For example, Moser-Mercer et al. (2018) argued that recent technology development offers alternatives for making higher education opportunities accessible through Open-Resource (OER) Materials and Massive Open Online Courses (MOOC). Wright and Plasterer (2012) also presented different models of e-learning, distance education, and university partnerships that can generate more opportunities for higher education. In light of recent advances in connected learning for refugees, *Localized Engineering* emerged as a promising alternative to fulfill the HE and TVET needs in displacement.

1.2.6 Relating Localized Engineering in Displacement to TVET and higher education

The main objective of the *localized engineering* model is to provide the students with an opportunity to attend an undergraduate introductory engineering course (higher education facet) and develop technical and labor-market relevant skills focused on local problems (TVET facet). The program included a LED curriculum integrating technical content, professional skills, and engineering design. The program focused on the needs identified by local students themselves. The purpose of the LED program was to offer a course for refugees situated between higher education and TVET and pedagogical innovation that recenters and relocalizes displaced students. In the LED model, displaced learners are learners, leaders, and citizens. The goal of recentering displaced young people in a tripartite role of engineering learners, classroom and community leaders, and engaged citizens has led to both immediate and sustained impact focused on community development (DeBoer, Radhakrishnan, & Freitas, under review).

1.2.7 Examining Localized Engineering within a humanitarian architecture

In our context, humanitarian architecture is a definition used to call attention to the complex cluster of humanitarian organizations in displacement (OCHA, 2007). This definition is important to highlight the importance of considering various actors to enable conditions to

achieve our outcomes. While the primary focus of this dissertation is to relate this study with refugee education frameworks, there is a need to ensure that the *localized* model provides interpretation to different actors engaged in crisis. Therefore, I situate the localized model as a program that provides mechanisms to support learners to interface with specific stakeholders within this cluster by using the engineering skills learned in the course. In doing so, I emphasize the importance of looking at engineering education as a program that aligns education with international goals by giving to learners the tools needed to tackle different humanitarian problems along with their specific groups to develop their community (See Figure 2).

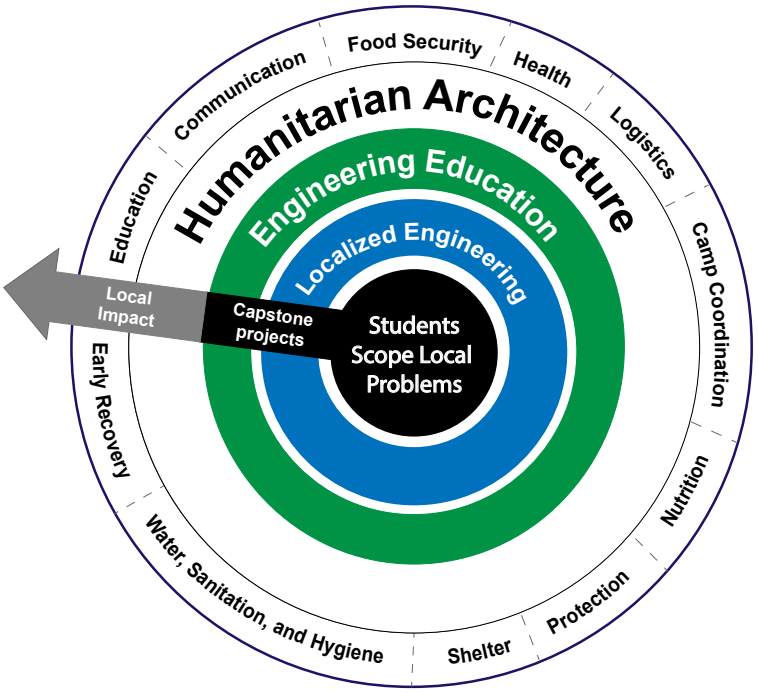


Figure 2. Relating *localized* engineering to the humanitarian architecture

For example, the GCR and GFRE provide a recent and comprehensive list of actors engaged in refugee education. However, these frameworks also contain some key limitations in terms of numbers of actors within each group as well as their level of implementation. Thus, it is important to recognize that findings from this study have an application limited to education. More specifically, the outcomes of our localized model need to build a solid cooperation across different humanitarian actors to achieve our goal. Given the complex nature and variety of international and national stakeholders in humanitarian context, further studies might be

necessary to expand the impact of this dissertation within this humanitarian architecture. In particular to refugee context due to diverse and unique contexts across countries. Overall, we present the *localized engineering* model as a pedagogical framework that uses engineering education to help displaced learners to address local needs in different dimensions, such as food security, transportation, water, etc. At the same time, we also consider that to enhance our impact with realistic solutions, it is required a collaboration with a complex humanitarian cluster formed by national and international agencies, donors, non-governmental organizations, and etc.

1.2.8 Connecting engineering education and community development

The critical role of engineering in addressing issues and challenges in humanitarian settings is widely recognized. Engineering practice enables the development of countries and communities (Lucena, Schneider, & Leydens, 2010). A report from UNESCO (2010) recognized that "engineering and technology are vital in addressing basic humans needs, poverty reduction and sustainable development" (p. 30). Also, engineering has been considered as a key player to plan, design, implement and develop solutions to address humanitarian challenges (Dandy, Daniell, Foley, & Warner, 2017). For instance, the role of engineering and technology has the clear role of providing resources and conditions, such as water (Harding et al., 2017; Nathan, Sharma, Nathan, & Kumar, 2014; Pichel & Vivar, 2017), food (Al-Addous, Saidan, Bdour, & Alnaief, 2018; Pottier, 1996; Saguy, 2016), and energy (Frack, Mercado, Sarriegui, & De Doncker, 2015; Fuentes, Vivar, Hosein, Aguilera, & Muñoz-Cerón, 2018). In the infrastructure and management domain, engineering also plays a role in creating solutions that address the development of livelihood conditions (Atmaca, 2017; Tomaszewski, Mohamad, & Hamad, 2015), logistics (Kovács & Spens, 2009; Trestrail, Paul, & Maloni, 2009), and communication (Bartalesi, S. Catusian, Cuomo, Longobardi, & Panicucci, 2009; Felton, 2015; Wall, Otis Campbell, & Janbek, 2017). These challenges are examples of opportunities where engineering and technology play essential roles in translating ideas into an immediate solution in the humanitarian context.

Engineering has been recognized as a fundamental tool to transform society (Wall, 2010). It can be used as a means to foster community development by providing the capability to support people in advancing and building better places (Gilbert, Held, Ellzey, Bailey, & Young, 2015; Schneider et al., 2008). Among numerous engineering education approaches for

community development, engineering design consists of a systematic and informed process to support students in learning and applying engineering concepts (Nieusma & Riley, 2010; Ranger & Mantzavinou, 2018).

While adopting user-centered approaches (Wilkinson & De Angeli, 2014), students see themselves as important players in conceptualizing these solutions and become social agents developing their communities. In this process, they no longer rely on international aid and they can rethink their perceptions of development towards social justice. The *localized engineering model* seeks to associate engineering design and the knowledge uniquely held by refugee learners to develop their understanding of community needs and feasible solutions. This approach emerged from the curriculum roots in social justice through components of critical pedagogy.

1.2.9 Social justice in engineering education

In this section, I discuss social justice in engineering education by summarizing Leydens and Lucena's (2017) work, and I subsequently expand to social justice in the classroom. According to Vasquez (2012), 'the meaning of justice, in its broadest sense, is "fairness"' (p.338), and it implies the sense of equity. As Leydens and Lucena point out, engineers design, build, and operate systems that influence the lives of millions of people. Consequently, engineering education needs a curriculum that embeds the great responsibility of engineers in transforming the world. However, such a societal approach needs to be addressed across different dimensions that occur from social to technical aspects. There is no single definition for social justice since this term deals with many facets of societal problems.

In general, engineering education for social justice implies a minimum criterion and intersection between a given problem and social factors related to it, and this intersection can lead to multiple misconceptions. These misconceptions are even more prominent among engineering students and novice engineers. For example, students perceive engineering as a profession focused on technical issues. Additionally, engineering faculty struggle in accentuating the connection between social and technical dimensions of design. Despite students' advances and interests of students in educational experiences and careers oriented towards social justice, the barriers to making social justice visible include the motivation to work with social justice and perceptions of social justice from political processes, structures, and institutions. Leydens and

Lucena (2017) concluded their work by discussing social justice as a vehicle for giving voice to marginalized groups. They also called attention to influence a new generation of students committed to enhancing human capabilities through engineering for social justice to build human capabilities.

There are several ways to foster social justice through education. Prior researchers explored the adoption of social justice in the classroom by using collaborative and participatory models, such as a community-based participatory approach (Jacobson & Rugeley, 2007; Voigt, 2018), school-based social justice (Howard & Solberg, 2006) and Youth Participatory Action Research (Tintiangco-Cubales, Daus-Magbual, Desai, Sabac, & Torres, 2016). Other researchers adopt pedagogical models for teaching/learning about poverty, oppression, and social justice, where education should promote liberty in terms of ideas and power to making changes in the social, political, and economic context through education (Darder, 2015). There are many ways to adopt social justice and critical pedagogy in the classroom, and educators should be aware of these strategies to adopt and adapt their pedagogy accordingly.

1.2.10 Adopting critical pedagogy in the classroom

Critical pedagogy, as described by Paulo Freire (Freire, 1970), can creatively be incorporated in the education system in order to respond to various social contexts, political and economic disruptions, and sociocultural justice (McLaren & Martin, 2004; Smyth, 2011; Wiggins, 2011). Some authors even discuss examples of tools that can be used in the classroom to foster critical literacy and critical thinking. For example, Lee and Soep (2016) suggested using computational tools geared toward culturally relevant, socially transformative, and helpful solutions for communities. They concluded that inserting the questioning of dominant ideologies with the creation of socially just tools would allow marginalized youth to learn their power in society.

Tetloff, Hitchcock, Battista, & Lowry (2014) also examined learning strategies based on technology tools that empower social work within education. The authors found that video tools can foster critical thinking by helping students to express commitment to social justice by compiling videos to craft interpretations of social policies in the classroom. Vakil (2014) expanded the notion of teaching tools and civil rights so that computational tool development should pose questions related to what, for whom, and for which purpose a tool should be used.

Other authors discussed strategies to adopt critical thinking as an element of pedagogy. Gunn (2016) proposes a strategy to investigate the historical and contemporary issues of individuals who have been marginalized by society and discuss issues of tolerance and social justice in order to demonstrate how groups of people can make a difference. The author found that critical experience provided content knowledge, emotional connection, and social insight.

Bajaj (2015) suggested a pedagogy of resistance to stimulate educators to provide learners with information and experiences that lead to knowledge, skills, attitudes, and behaviors that promote peace. In another article, Sangster, Stone, and Anderson (2013) studied the teacher's self-consciousness in developing their understanding of the transformative nature of critical pedagogies. Their study explored the teacher's views on the use of critical literacy in their pedagogical practices as well as how essential methods of literacy are presented in the classroom. They concluded that teachers could learn critical literacy and take this ahead in their own teaching.

Other researchers discussed barriers and constraints in implementing critical pedagogy into a school system. For example, within engineering education, faculty members can struggle in grasping the term social justice given this complex dimension of definitions and terms in engineering and social justice (Leydens & Lucena, 2017). Freire and Valdez (2017) argued that lack of time and culturally relevant materials, lack of knowledge, and inappropriateness of social justice in the educational content represent significant barriers in the educational environment so that a dialogic process of reflection and praxis is necessary to overcome some of these obstacles. They also found that offering guidance and support to teachers while they are learning social justice becomes necessary, especially in their first years of teaching.

Similarly, Gerdin, Philpot, and Smith (2016) also identified challenges for educators to adopt critical pedagogy in the classroom, such as the difficulty of changing students' practices through a single course and a pattern in teachers revert back to the type of transmission-based pedagogy they knew best from their own formal school experiences. The reason for this last challenge is a lack of concrete examples of how to engage in critical praxis. In light of existing challenges to adopting a justice-oriented curricula, Dover (2016) suggested four steps should be taken to introduce justice-oriented practices in the classroom. First, teachers should unpack their understanding of social impact. Second, the context of the study and social dimensions are important, and teachers should pay attention to it. Third, teachers need to examine connections

across justice-oriented curriculum, and pedagogical goals. Lastly, teachers should establish a connection with justice workers in their school or community.

1.2.11 Social justice in higher education

The relevance in creating a sense of connection between social justice and higher education is discussed by McArthur (2011) and Giroux (2010), where they recognized the importance of creating a spirit of critical democracy in higher education. On the other hand, there is a common concern about the nature of democracy in the educational contexts. Students should be guided to understand the larger world as agents of change. Students should be educated not only about work and economics, but questions of justice, social freedom, and the capacity to become agents of change to promote social justice on every discipline.

In the context of engineering education, Claris and Riley (2012) examined the role of critical thinking not only within but also about engineering. Building on how engineers connect social justice and their professional skills to take practical action for change, Claris and Riley studied how critical thinking influences the power of relationship and its epistemic assumptions by investigating how learners grasp the relationship between technical and social elements. Additionally, teachers should consider the complex task to unpack definitions and conceptions of social justice in education. Kabo and Baillie (2009) examined this conceptual challenge about social justice in education and they found that students have multiple lenses of social justice for engineering. Therefore, they suggested pedagogical actions to help the deconstruction and critical analysis of engineering practice. Berg and Lee (2016) also examined the introduction of social justice within the engineering curriculum, arguing that the inclusion of critical pedagogy in engineering programs is commonly linked to a matter of accreditation that can lead to students experiencing challenges to get exposed to topics critically important. Berg and Lee concluded that integrating topics such as ethics, social justice, and social responsibility needs more attention because it can influence student's point of view about the role of engineers in the world.

Regarding engineering education and social justice, Smith et al. (2019) examined engineering education programs with principles of humanitarian action and development, and they identified 67 university programs that work towards human development. According to them, the number of engineering programs linked with humanitarian action increased since 2000. But to whom are these programs in service? Often, the most well-resourced students are more

able to access these programs; further, at a macro level, these are often programs at higher-resourced institutions from educational institutions in developing countries. While many programs do successfully focus on and expand privileged students' perspectives to be aware of global inequality, they do not prioritize the students and community *experiencing* that inequality (as noted by Ruyle, Boehm, and Lagoudas 2016; Nieusma and Riley 2010; and others).

As Riley (2007) points out, universities offer a wide number of approaches for global education, such as study abroad and exchange programs, programs for global studies in engineering, courses in sustainable and/or appropriate technology education, and co-curricular models. It is important to engage the engineering education community to discuss the underlying assumptions that surround this explosion of interest in global development. For example, according to Riley (2007), these programs offer drawbacks that need to be highlighted in further discussion, such as study abroad programs that poorly emphasize the economic, political, and cultural dynamics, global studies that fail in engaging students in critical thinking, technology courses that overlook that competition between the needs of the engineering students and the community's needs, and inefficient allocation of resources to deploy co-curricular models.

1.2.12 Relating social justice with localized engineering model

The *localized engineering* model is strongly rooted in social justice through components of critical pedagogy. Critical pedagogy can open space where teachers and students can empower themselves to inhabit their role as critical agents in society. The *localized model* supports learners in displaced communities in questioning the educational system and social power structures through critical thinking to improve their own conditions. Overall, Freire (1970) discussed this pedagogy by defending that change is possible through a process of *conscientização*, a Portuguese term used to explain the process of awareness of social justice and desire to take action to promote equity and citizenship. *Localized engineering* engages in critical pedagogy in two ways. First, the curriculum explicitly supports students' agency, both in micro-issues (e.g., students agree together on rules/penalties for course management) and in more fundamental ways, e.g., supporting their agency and charging them with coming up solutions to challenges in their community. Second, as the class moves forward, learners and instructors co-create and iteratively improve the course, localizing it based on students' guidance and on course

graduates' perspectives (mainly when they then facilitate the course), continuing to support their growth as both learners and leaders.

In addition to learner support, the localized curriculum seeks to support facilitators and local instructors by offering guidance in terms of helping them to support the social agency within the classroom. For example, common course policies are co-created with students where learners are free to come up with any ideas in the course and we support local teachers and facilitators by offering guidance to support learners' ideas. Besides that, the entire curriculum is grounded in helping students to perceive their role as social agents. It includes the examples used in the classroom or even the scope of the capstone projects that are recommended to address local problems. Overall, the *localized model* seeks to translate the idea of critical agency within a course daily basis where students and facilitators are continuously developing a sense of empowerment and social agency during and after the course completion.

1.3 Overall Research Approach

This dissertation presents three studies that are part of a larger research endeavor to assess and improve online learning spaces for at-risk engineering students. The name of the larger study is "Assessing and Improving Online Learning Spaces for Diverse and High-Attrition Engineering Students" and is funded by the National Science Foundation (NSF) under Grant DUE #1454558. The larger study has four research questions that ask about 1) how quantitative effects of online programs and tools persist for at-risk learner demographics, 2) how online teaching predicts higher achievement for these students, 3) how the fragile context influences student behaviors and outcomes, and 4) the implications of these findings are for future research and educational policy. The diagram in Figure 3 provides a description representing connections between the three studies of this dissertation. In this figure, all three papers play a fundamental role in sustaining the LED model discussed in this dissertation; however, it is important to notice that paper 3 also takes advantage of my findings and insights from paper 1 and 2.

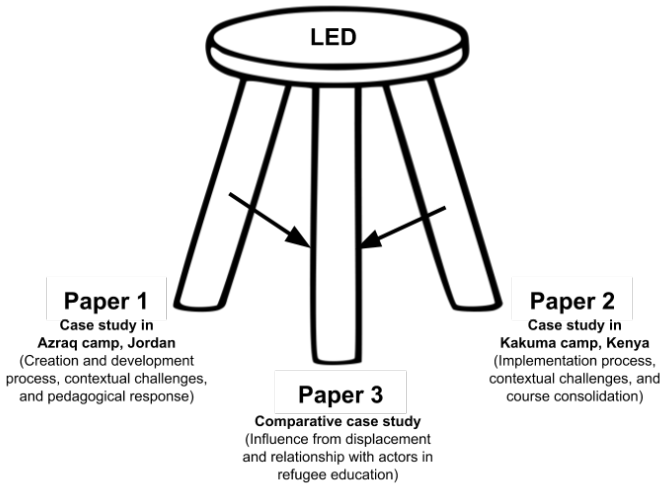


Figure 3. Diagram representing connections between the three studies of this dissertation

1.3.1 Research Methodology

This dissertation consists of a qualitative case study (Yin, 2014) to explore the development and implementation of an undergraduate engineering course for refugee learners in a Kenyan and Jordanian refugee camp. A qualitative approach was necessary to understand the complex settings in which the research is taking place and the exploratory nature of this study. The interpretations in this dissertation were constructed based on a constructivist paradigm and the exploratory case study methodology was employed in this dissertation for several reasons. First, I am not interested in sampling research or even interested in understanding other cases since my research consists of outlining the course and participant experiences in both camps only. Second, the primary phases of this dissertation were not guided by a specific research question. The initial approach in the creation and implementation of this study was guided by a broad research and practice aim informed by the large studies, and more precise research questions for this dissertation only emerged after exploring the data. Third, the boundaries between the phenomenon and context are not evident, so that multiple sources of data are necessary to investigate within this specific context and case studies offer this openness to triangulate and refine the data source. Lastly, given the complex nature and uncertainty in refugee settings, the case study offered flexibility to take research design decisions based on the uniqueness of each case. In the next sections, I provided an overall description of my research methods and design decisions.

1.3.2 Research participants and classroom context

These three studies were conducted in a Jordanian and Kenyan refugee camp with a total of 55 students, ages 18 – 51, living in the Azraq camp from 2017 to 2019, and a total of 38 students, ages 18 – 34, living in the Kakuma camp in 2018 and 2019. Table 3 represents the number of research participants and camps associated with each of the three studies (named as Chapters) in this dissertation conducted over three years.

Table 1. Student samples associated with dissertation chapters

Chapter organization	Refugee Camp(s)	Year of Data Collection	Number of Students
Chapter 2	Azraq	2017, 2018, 2019	55
Chapter 3	Kakuma	2018, 2019	38
Chapter 4	Azraq and Kakuma	2017, 2018, 2019	93

The Purdue institutional review deferred approval to the University of Geneva for consent for all data collection activities, and ethical issues considered included confidentiality and voluntary participation. These forms were provided in English and translated adequately to research participants if necessary and are provided in Appendix C. Details regarding the engineering projects, technology tools used in the course, and the refugee camps used as case studies are provided in the following paragraphs.

edX Online Platform

The online learning environment implemented in both refugee camps involved using edX Edge platform to deliver the lectures, videos, images, surveys, and upload course assignments. Edge is part of the edX platform, which is a non-profit, massive open online course (MOOC) provider that allows free access to online courses (https://edge.edx.org/). This platform was used as the main online interface with refugee learners. As students interacted with the online platform (see Figure 4), they could access the learning resources and upload their assignments at any time by using computers or cell phones. We also used the platform for formative assessment and data collection.

Figure 4. Students in Azraq (left) and Kakuma (right) using the edX Edge platform

In edX Edge, instructors could create and design class structures, online forums, and other activities like simulations to engage learners in the learning process. Learners and facilitators were able to transition between slides at any time and according to their needs. An online studio was available to support instructors to create the teaching resources for each class. Additionally, the platform allowed the integration of multiple tools, multimedia, and simulation.

Online Forum

The course offered an online forum through a messaging app called WhatsApp (https://www.whatsapp.com/). This app is a free social network messaging application that allows users to communicate and share a variety of media: text, photos, videos, documents, and calls. In addition, messages and calls are secured with end-to-end encryption. WhatsApp also allows users to create groups with up to 50 members and it works across multiple platforms. In this forum, learners and instructors could report course updates, share opinions, discuss assignments, or interact with peers. WhatsApp was selected given the combination of these features, the familiarity of our learners with this messaging app, and the emerging evidence that these apps and social media can support the learning process (Mnkandla & Minnaar, 2017; Robles, Guerrero, LLinas, & Monteiro, 2019; Stone & Logan, 2018).

Electronic Components and Tools

The Purdue team equipped the classroom with the electronic components and tools needed to develop activities and capstone projects throughout the course. The tools were purchased in

local stores based on the course needs and students' demands. The list of equipment purchased, presented in Appendix E, consisted of the same items for both camps considering their availability in the local market. The electronic equipment enabled students to practice the theory learned in the course by developing and testing their own circuits. Given the difficulties of repairing or replacing equipment in the camp, we purchased spare components in case of damaged equipment. Figure 5 presents students actively engaging with the electronic equipment available in the classroom.

Figure 5. Students in Azraq (left) and Kakuma (right) using electronic equipment

Engineering design process and capstone projects

Students developed capstone projects addressed to local challenges by using the engineering design process (EDP). EDP, as taught in this course, covered the following elements: need-finding, problem identification and scoping, concept reduction and selection, evaluation, testing, prototyping, and communication. In addition, a professional engineer came to class and discussed engineering design and problem-solving in his daily work as an engineer in the camp. At the end of the course, students presented their final project. In this presentation, we evaluated their performance through a specific rubric designed to capture and evaluate their overall performance in meeting learning goals and objectives. These presentations were evaluated by a variety of stakeholders, including the instructors themselves, local personnel, and the same practicing engineer in the camp. The learning goals assessed on the final project addressed evidence-based decision making, engineering ethics, idea fluency, professional

communication, problem scoping and solution quality. A complete representation of the final rubric is presented in Appendix D.

Examples of capstone projects

The capstone project is an essential component of our pedagogical framework. The project-based approach guide students throughout the engineering design process while they take leadership in their community to find problems and come up with solutions using a systematic process. Some examples of capstone projects developed in the courses with their respective descriptions provided by students themselves are:

- **Title**: A solar system for the mosque

Place/Year: Azraq/2017

Description: Students designed a solar PV system for the village mosque and created a prototype to demonstrate their application. According to them, "the goals of our project are to use clean energy source to feed the mosque and save the power by using photovoltaic panels (PV), microcontroller (Arduino) and sensors; for example : light sensors to turn off the lights when there is no need to use it, motion sensor to turn on the lights inside the toilets if anyone comes in, and temperature sensor to control the air conditions. By using these sensors, we can control power consumption."

- **Title**: 3S Project (named by students themselves)

Place/Year: Azraq/2018

Description: 3S is an acronym that means "Smart Safety System." This is a smart system designed for monitoring and protecting shelters against fire and gas leakage. While this system contains several sensors and subsystems, the overall idea is simple. 3S is simply an early warning system. Cheap, useful, Easy to use and reliable for protecting and controlling conditions in our shelters in Azraq refugee camp.

- **Title**: Water management system

Place/Year: Azraq/2018

Description: Students built a system that measures moisture in the soil because they live in a desert area with high temperature and low humidity. The system can turn on water pumps or off

when needed. The system also contains a temperature and humidity sensor to monitor the current temperature and humidity in the air and compare them with tables which will be used for comparison purposes for the plants that we will plant in the garden.

- **Title**: Biomass grinder project

Place/Year: Kakuma/2018

Description: In Kalobeyei Camp, production of charcoal is only dependent on manual work. The women benefit from a locally available tree with high calorific value, but the manual work is always difficult for them. “We need to design and develop biomass grinder that will be more efficient than the unsafe and inefficient manual work process.” Thus, they proposed a grinding machine powered by biomass or hybrid can be a solution rather than manual process.

- **Title**: Briquetting machine

Place/Year: Kakuma/2019

Description: In this project, students identified that people are suffering from where to access enough firewood to use for cooking. Due to that condition, students came up with ideas of how to overcome the problem concerning for enough fuel for cooking. Briquetting machine will save bill and energy of the host community who waste their energy and struggle to produce charcoal manually because the briquetting machine will work automatically.

1.3.3 Refugee Camp Implementations

The two case studies examined in this dissertation are the Azraq refugee camp in Jordan and the Kakuma refugee camp in Kenya. We decided to implement the course in both camps given the existing collaboration and partnership between the research partnerships and humanitarian actors in these two camps. The space available for course development consisted of a single classroom in both refugee camps with limited access to the internet and electricity (see Figure 6).

Figure 6. Learning spaces in Azraq (left) and Kakuma (right).
Right figure reprinted from Al-Fanar Media, Retrieved from https://www.al-fanarmedia.org/2016/09/digital-learning-refugee-context-building-back-better/.

The course framework consisted of many phases, as shown in Figure 7: Course preparation, course recruitment, pre-course workshop (distribute and collect consent form), entrance exam, course kickoff, end of the course (and certificate deliverables), independent projects callout and subsequent follow-up.

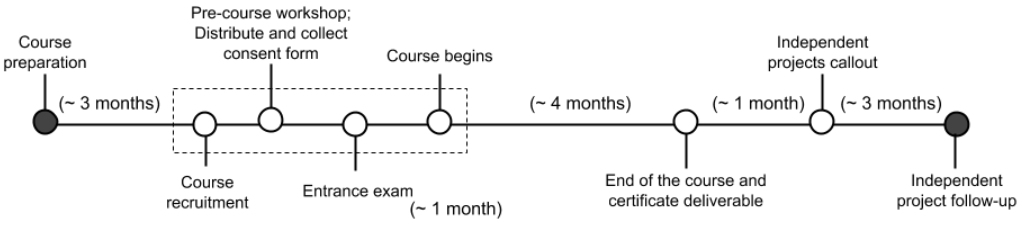


Figure 7. Timeline of the course development

- *Course preparation*: The course preparation was coordinated between the instructor team, international, and local partners. As part of this process, we engage with local partners to understand the reality on the ground. We also use this stage to iteratively evaluate our content, assessment, and pedagogy to adapt our course accordingly. Overall, we adapted the type of assignments, assessment, slide content (e.g., examples of activities and language of instruction), and scope of capstone projects based on local needs.
- *Course recruitment*: The recruitment process was coordinated with local partners to disseminate the course callout in the camp through paper-printed flyers. On the flyer, we included information about the minimum criteria to enroll in the course and expected outcomes.

- *Pre-course workshop*: The pre-course workshop consisted of a three-day on-site session, where we introduced the instructional team. We also provided an overview of the LED curriculum so that students could get a sense of how and what they would learn in the course.
- *Entrance exam*: A written test where students answered word problems in both English, French, or Arabic, basic logic and math problems, and wrote a motivation statement.
- *Course kickoff*: The course kickoff was decided based on a common agreement between instructors, learners, and local management. This decision considered factors related to job conflict, time restrictions in both camps, and convenient time zone differences both learners and instructors.
- *End of the course*: The course culminated in multiple capstone projects where groups of four students with common interests worked together. Students were equipped with electronic tools, software tools, development boards, and technical training tailored to develop projects addressed to local problems in the camp using the engineering design process.
- *Independent project callout*: Individual impact is clearest in "independent projects," which students can pursue after the class. These projects provide opportunities for them to take their individual prototypes and implement them in their homes and in public spaces for the community. We provided a few weeks where students could get familiar with the process to structure their proposal before submitting the project.
- *Independent project follow-up*: During the project development, we actively engaged with students bi-weekly to check in on their progress and assess their development in order to identify potential gaps to advance the project implementation.

Additional detailed information about each course phase are described in Chapter 2, 3, and 4 in this dissertation. In the next sections, I explain each refugee camp in more detail.

Azraq Refugee Camp

The Azraq camp has been a temporary home for 40,000 Syrians since 2014, and it is located in an empty desert area (United Nations, 2014) in the province of Zarqa Governorate in central-eastern Jordan, 100 km east of Amman (UNHCR, 2019f). The decision to allocate the

camp in the desert was taken due to the high forced migration of refugees arriving in Jordan daily (Dalal, Darweesh, Misselwitz, & Steigemann, 2018). Common challenges that affect the Azraq camp are the need for improvements to shelter design to protect people against the harsh desert weather conditions, to water management systems, and to avenues for freedom of movement to leave and access external aid (Al-Bakri, Shawash, Ghanim, & Abdelkhaleq, 2016; Dalal et al., 2018; Hoffmann, 2017). Another important characteristic from the Azraq camp refers to its population, where the demographic distribution consists of Syrian refugees setting up a monocultural context. The course in the Azraq camp worked under the guidance of local facilitators recruited by our local partners to support the course development over four months on average and two classes a week of approximately 120 minutes each. Table 2 presents the class schedule in the Azraq for each year implemented in the camp.

Table 2. Class schedule in the Azraq camp

	Course schedule in Azraq		
Year	**2017**	**2018**	**2019**
Course length	April – July	February – June	February - June
Number of classes	24	24	24
Time per class (h)	2	2	2
Students enrolled	28	15	12
Facilitators	2	4	4

Kakuma Refugee Camp

The Kakuma refugee camp was established in 1992 in north-eastern Kenya, and it has grown in the population of refugees it caters to over the past two and a half decades. With a population of over 191,500 registered refugees and asylum-seekers (UNHCR, 2019b), the Kakuma camp is one of the world's largest refugee camps. Refugees in Kakuma experience many challenges, ranging from differing forms of insecurity (Crisp, 1999), lack of access to improved sanitation (Nyoka et al., 2017), harsh environment (Bartolomei, Pittaway, & Pittaway, 2003), poor education quality (Mareng, 2010), and political restrictions. Added to these challenges, Horn (2010) pointed out that limits for employment make refugees almost totally dependent on agencies to provide for their basic needs (p. 162). The Kakuma refugee camp population consists of people from Somalia, Uganda, Sudan, South Sudan, Burundi, Democratic Republic of Congo, Eritrea, and other countries in the region (UNHCR,

2018a). In Kakuma, it is common for a refugee to be able to speak Kiswahili, French (depending on their country of origin), and in some cases, the third language in addition to English. Given the variety of countries of origins and languages spoken in Kakuma, it is also valid to mention the multicultural context that influenced the course dynamics in terms of collaboration and cooperation, for example.

Following the launch of the LED course in Azraq, Jordan in 2017, we launched the course in Kakuma camp in 2018 and facilitated a second course in 2019. The data analyzed in this study comes from both classes. The course in Kakuma also worked under the guidance of local facilitators to support the course development over four months on average and two classes a week of approximately 120 minutes each. Table 3 presents the class schedule in Kakuma for each year implemented in the camp.

Table 3. Class schedule in Kakuma camp

	Course schedule in Kakuma	
Year	**2017**	**2018**
Course length	February – June	February – May
Number of classes	24	24
Time per class (h)	2	2
Students enrolled	20	18
Facilitators	2	4

1.3.4 Case Studies

This section describes the case studies and provides a rationale for my research methods. The qualitative nature of my study allowed me to study and collect a variety of personal experience, introspection, interviews, course artifacts, observation, and visual texts to describe the perspective from course participants throughout their progression. In this dissertation, I described in my first study (Chapter 2) my process to conduct the case study to investigate localized engineering in the Azraq camp. Then, I described in my second study (Chapter 3) how I used the case study to investigate localized engineering in Kakuma camp. Lastly, I described in my third study (Chapter 4) a comparative case study to investigate my research questions through different dimensions across both camps.

While case study is widely used in social science and education research, doing a case study is also challenging (Yin, 2014). According to Hyett, Kenny, & Dickson-Swift (2014),

several issues can affect methodological integrity in case studies. Hyett et al. (2014) pointed out that common mistakes in case studies are: lack of information to understand the case selection, poorly described contexts, inconsistencies between study components, and limited description of study design, paradigmatic approach, positionality, and description of the analytical process. Addressing these methodological issues is important because it helps the reader to evaluate the extent that case studied can be generalized or not to a different contexts (Ward, 2002; Tripp, 1985).

In this dissertation, the cases selected were the engineering courses in Azraq and Kakuma based on existing connections with local stakeholders by our international partners. I decided to select these two cases given the unique opportunity to examine engineering education within two camps that reflect good representative cases of displacement to situate my work. I provide more information about settings and participants in my study in Chapters 2, 3, and 4. In terms of my research analysis, I used thematic analysis (Braun & Clarke, 2006) given its flexibility and freedom to outline my themes and findings without implicit theoretical commitments.

To provide a clear representation and differentiate my studies, I used multiple figures, one representing each study. Figure 8 represents my case study design focused on Azraq in Chapter 2. Figure 9 represents my case study design focused on Kakuma in Chapter 3. Then, Figure 10 represents the comparative case study between Azraq and Kakuma in Chapter 4. The outer rectangle represents the context of each study. The first inner rectangle represents the case(s). The internal rectangle with the dashed line represents the units of analysis of the study.

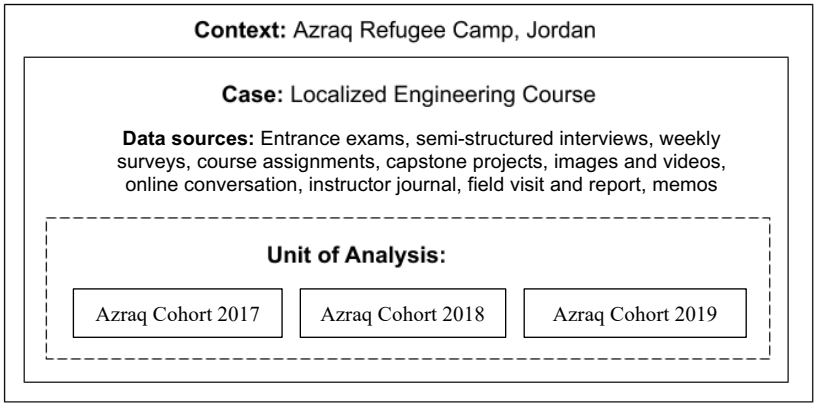


Figure 8. Case study framework in Azraq camp

Note. Modeled after Yin's (2014, p.50) example taken from COSMOS Corporation's "Basic Types of Designs for Case Studies."

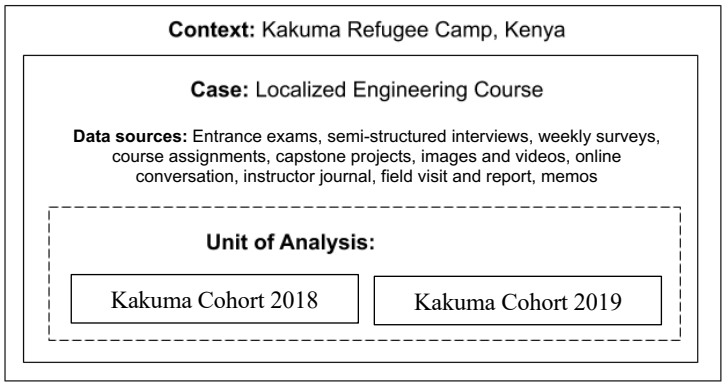


Figure 9. Case study framework in Kakuma camp

Note. Modeled after Yin's (2014, p.50) example taken from COSMOS Corporation's "Basic Types of Designs for Case Studies."

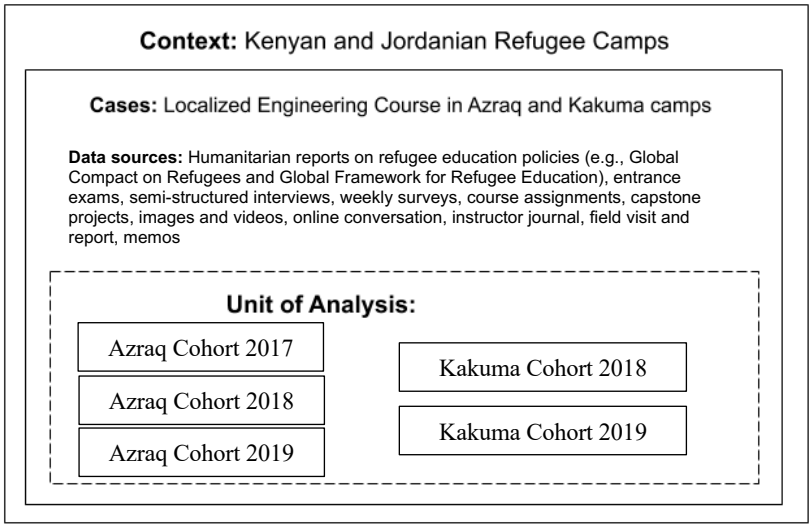


Figure 10. Comparative case study framework in Azraq and Kakuma camp

Note. Modeled after Yin's (2014, p.50) example taken from COSMOS Corporation's "Basic Types of Designs for Case Studies."

Data collection

My research instruments comprised of multiple data sources. This section describes the different source of data as shown in Table 4 and my data collection process.

Table 4. Data collection instruments

Instrument Title	Appendix Letter
Entrance exams	F
Semi-structured interviews	G
Course assignments	H
Capstone projects	I
Online forum	J
Instructor Journal	K
Field visit and report	L

1) *Entrance exams*: A paper exam managed by local facilitators where students answered word problems in both English and Arabic, basic logic and math problems, and a motivation statement.
2) *Semi-structured interviews*: The interview protocols for students and facilitators contained 21 open-ended questions and generally took from 40 to 130 minutes by phone. Interviews were recorded and transcribed. The interviews were structured around participants' experience in the course, motivations, and their processes to work on capstone projects.
3) *Course assignments*: A wide variety of individual and group assignments to assess different skills throughout the course. In this course, the course assignments consisted of: in-class quizzes, computer projects, design and analysis projects, oral presentation, lab exercises, design book, and capstone project.
4) *Capstone projects*: A course assignment that serves as a culminating project for students, where they develop a solution for a local problem identified by themselves. The capstone project consists in a final product, oral presentation, and written report where they described their processes, experiences, theoretical foundations, and conclusions.
5) *Online forum*: An online forum on WhatsApp where we can talk to students, facilitators, and local staff about course events, experiences, and issues occurred during the class. Course participants also engaged in this forum to share their experiences, thoughts, and course artifacts, such as images, videos, and assignments.
6) *Instructor journal*: A written report to reflect on experiences before and after each class. Each reflection contains my impressions about what happened before, during, and after each class session. I used a template for every class where I synthesized main events that help me later on in my analysis.
7) *Field visit and report*: A written report to represent the views and perspectives of the research team during field visit. It includes our perceptions about the camp, local staff, students' dynamics, and other impressions collected during the kick-off workshop that will help to the data analysis.

Overall, the data collection and analysis had four phases (see examples in Appendix R). The first phase provided an in-depth evaluation of my data sources. This evaluation included examining the facilitators, learners, and online instructors' experiences throughout the creation and implementation of the course. During this first phase, I had the opportunity for reading, handling my discoveries, and building an overall understanding of the data. Phase two consisted of individual analysis for each study by looking at their specific research questions and

triangulated with my findings from phase one until achieving data saturation. Phase three consisted of the application of thematic analysis for each study using a variety of methods, such as triangulation, peer-review across research members, and member-checking with research participants. This third phase employed the use of open, axial and selective coding. I inductively constructed themes and meaning from each study to develop my ideas. This inductive process was done for each study grounded in their respective research questions, and the components of each remained separate until they were further analyzed and compared in the fourth phase.

Trustworthiness

Aligned with recommendations from literature to establish trustworthiness on my case study (Hyett et al., 2014; Yin, 2014), thematic analysis (Braun & Clarke, 2006; Nowell, Norris, White, & Moules, 2017), and qualitative research approach (Denzin, 2017; Tracy, 2010), I used seven techniques.

8) *Triangulation*: I collected the data from multiple sources and performed a cross-analysis. I also used multiple participants to look for similarities and differences within and across camps. A more comprehensive analysis and presentation of my coding and findings was possible through the use of multiple participants and perspectives, as well as my own perspective.
9) *Peer debriefing/examination*: I used member checking as a second component of the triangulation process where the research members and partners involved in the project were asked to clarify the information and data collected. I also constantly presented my study findings to peers to receive their comments and obtain their perceptions.
10) *Member checking*: I discussed my preliminary analysis and overall findings with course participants in order to eliminate my own bias when analyzing and interpreting data. I also used member checking as a component of triangulation. This technique also helped me to test my analysis and interpretation against the data collected.
11) *Prolonged engagement*: I actively engaged, co-created, and implemented the localized engineering course in both camps since its genesis from 2016 to 2019. I also visited both camps and continuously interacted with all course participants throughout the course via an online forum and private messages.
12) *Purposive sampling*: I selected participants for my interviews based on certain criteria, such as role and engagement in the course, as well as selected learners who were particularly knowledgeable of the issues in each camp.
13) *Co-recode strategy*: The different phases of my research allowed me to code-recode the same data multiple times, giving more time and analytical thinking to perform data processing. This process also helped me to improve my understanding of the linear narratives and events throughout the course.
14) *Audit trail*: I systematically kept track of decisions relating to the projects in order to map the steps taken and changes made throughout the course. It included a record of

transcripts, field notes, and course events, research memos, data analysis diagrams, and detailed information about the comparative case study.

1.3.5 Positionality

Research is a shared space constituted by both the researcher, participants, and audiences (England, 1994). In addition, in terms of qualitative research, the researcher is also considered as a data collection instrument (Denzin & Lincoln, 2018) and my positionality can affect the ways I see my research (Temple & Young, 2004). Hence, it is fundamental to situate the role of the researchers and their impact on the research process. As a researcher, engineer, and educator, I positioned myself as an instrument to critically analyze my findings as an outsider and situate it within the existing literature on engineering education and education in displacement. I am an engineer pursuing a doctorate in engineering education who has neither lived as a refugee nor experienced (Purdue's specific version of) Introductory Engineering Course as a student. I have a bachelor's degree in mechatronics and a master's degree in electrical engineering, and professional experience at the university level.

The course was part of my doctoral research in Engineering Education at the School of Engineering Education at the Purdue University and my positionality gave me a unique understanding of the nuances and events that surrounded the course development. I collaborated with many experts in engineering education, education in displacement, engineering design, and qualitative research experts to ensure the quality of my work. In this dissertation, my active role in the course development from its beginning, my interaction with different actors and stakeholders throughout the course implementation, and field experience in both camps allowed me to triangulate events that emerged from my data analysis with contextual events that occurred throughout the course. I also interacted with all students and facilitators from the beginning until the end of the course. This interaction gave me an in-depth perspective of their experiences, including students who dropped off.

Overall, my positionality offered me conditions to have access to particular feedback or thoughts from course participants due to long term engagement and continuous interaction with them. Consequently, this closer relationship helped me to triangulate and perceive events that are not clearly described from data sources. On the other hand, I am also cognizant of the limitations of my positionality. For example, I recognize that even though I put efforts to create stronger

connections with students, I might have missed certain aspects in the class due to distance learning and power differences perceived by the students. For example, during my analysis, it was found that students showed confidence with their course progress in the online forum while communicating in English; however, they demonstrated a different opinion and showed lack of confidence when talking to their peers in their native language. Additionally, I had to establish barriers on how I perceived the events in the course and analyzed my data sources given my in-depth relationship with students and facilitators after the course completion in Azraq and Kakuma.

1.3.6 Researching with refugees

In light of the growing concern for disseminating respect with research participants in fragile contexts and the focus on research ethics with vulnerable participants (Fox, Baker, Charitonos, Jack, & Moser-Mercer, 2020), ethical reflexivity plays a significant role to minimize the risks of research in a vulnerable condition (Block, Warr, Gibbs, & Riggs, 2013) and it helps to improve the education outcomes in humanitarian and crisis contexts (Accelerator, 2019). A number of researchers recognized the methodological and ethical considerations in research involving refugees (Block et al., 2013; Ellis, Kia-Keating, Yusuf, Lincoln, & Nur, 2007; Hopkins, 2008; Pittaway, Bartolomei, & Hugman, 2010).

Many practical problems arise in research with refugees when using conventional research methods. Pernice (1994) underscored six methodological problems in refugee settings, "(a) contextual differences between migrants and the receiving society, (b) conceptual problems with the translation of instruments, (c) sampling difficulties, (d) linguistic problems, (e) observation of etiquette, and (f) personality characteristics of researchers" (p. 207).

Several contextual challenges also influence the design and development of research in refugee camps. Examples of these challenges include constructing long-term partnerships with local partners and community, problems with representativeness, gaining access to the refugee community, limited data collection, psychosocial issues, and economic incentives for the community and research participants (Ellis et al., 2007; Fegert, Diehl, Leyendecker, Hahlweg, & Prayon-Blum, 2018; Head, 2009; Jacobsen & Landau, 2003; Pittaway et al., 2010). Additionally, there are particular types of danger for research in refugee camps. Block et al. (2013) pointed out that sensitive circumstances, as well as cultural and linguistic differences between the research

and participant also increase the research complexity. Thus, research methods need to allow for a "flexible, reflexive, and empathetic approach" (p. 75) to mitigate these complexities.

The existing trend in working with members from the community, while meeting some participatory goals, can also create unintended consequences. For example, the participatory approach never includes all sectors in the community, given the complex socio-cultural and management dynamics across different communities, and those who are recruited are often chosen because they were easier to be selected (Temple & Moran, 2006, p. 14). Also, in my experience, there are critical factors in terms of who speaks for the community, given the power dynamics across local managers and refugees within both camps, which can direct to issues of representation and accountability (Wilson & Wilde, 2003). Our team considered these complex dimensions and attempted to balance the numerous demands between research, ethics, and refugee populations to enhance the scientific rigor of this dissertation and meet the goals and protection needs of our collaborators. For example, we co-created the course pedagogy and assignments in order to enhance the sense of belonging and community with research team. In addition, our *localized engineering* model shifts the course responsibility to the local community in order to ethically and actively engage course participants in research and pedagogical decisions throughout the course.

Ethical considerations in refugee camps are important because they call attention to specific issues resulting from vulnerability and fragile settings. Refugee camps are considered a place of dissolution and new life (Turner, 2016) and often understood as a humanitarian, political, and emotional space (Feldman, 2015). Translating these concepts about refugee camps into research requires multiple considerations regarding the nature of the study. For scholars working with refugees, the researcher is responsible for the participant. However, the responsibility to work with refugees receives little attention from the literature (Aidani, 2013). Also, it is often dominated by issues with "power and consent, confidentiality and trust, risk to researchers and potential harm to participants, as well as the broader cross-cutting issues of gender, human rights and social justice" (p. 232). Thus, considerations regarding using research to promote the impact in the local community and local development are overlooked.

Overall, there is a common critique of the social impact in the real world from academic research (Shucksmith, 2016). On the other hand, recent findings demonstrate a number of ways in which rigorous scientific research can help to improve the daily challenges of displaced

populations (Donnelly, Raghallaigh, & Foreman, 2019; Freitas, Beyer, Yagoub, & DeBoer, 2018; Gottlieb et al., 2017; Habib, 2019; Norton & Sliep, 2019; Vainer & Shohat, 2018). Recognizing these complex dimensions between research, ethics, and refugee populations help to enhance the scientific, rigorous, and validity of studies in similar settings to use academic research as a tool to foster social justice.

1.4 Chapter Organization

In this dissertation, I present three interrelated studies linked by their interests to advance engineering education in refugee camps. Chapter 2 discusses the processes to develop and implement the LED course for tertiary learners in a Jordanian camp. Chapter 3 describes the creation and implementation of the LED course in a Kenyan Camp. Chapter 4 uses comparative case analysis to understand the challenges that influenced the LED in refugee settings and to what extent different actors collaborate to support the development of the course in a similar setting. Chapter 5 illuminates the findings across my three studies and discusses general outcomes to engineering education in refugee camps. Summaries of the three studies that constitute Chapters 2-4 are provided in the following section.

1.5 Contribution

This dissertation is impactful for refugee education in pedagogical and political aspects. The LED course presented in this dissertation is the first study of an engineering education program within and for tertiary learners in refugee camps. Most education opportunities in refugee camps prioritize basic or secondary education opportunities and non-engineering related skills. In addition, engineering education approaches in refugee camps generally come with outside expertise, which can motivate international agencies to address the responsibility of TVET programs to develop local technical and entrepreneurship skills.

Chapter 2 offers the first engineering education study to formally investigate an introductory engineering course in refugee settings that offer a higher education opportunity for refugees and provide technical training. This chapter also presents a pedagogical model for other educational researchers to create and adapt their engineering and technical courses to similar

refugee settings. The study outcomes are grounded in research-driven approaches to develop a course and pedagogically respond to local challenges in refugee settings.

Chapter 3 provides a rigorous study to analyze the process to implement and adapt the LED course to another refugee camp, the Kakuma refugee camp. Considering the LED model provided in Chapter 2, Chapter 3 provides a comprehensive study to help instructors and researchers to identify the role of contextual challenges. Then, critically evaluate the adoption of the LED course in different national and cultural contexts, which helps to consolidate the findings presented in Chapter 2.

Chapter 4 is the first study to examine engineering education within the pedagogical landscape and policy arena in refugee camps. Thus, Chapter 4 provides a framework for engineering education researchers and actors involved with refugee education that can help to advance engineering education programs in refugee settings. Without considering a multi-actor network in refugee education, the opportunities for developing more effective calls for HE and TVET for refugees are being missed. Furthermore, Chapter 4 could provide the foundational theory to allow HE and TVET trainers to create appropriate course activities that build their outcomes on local assets helping to prepare locally engaged learners.

Overall, using engineering education to foster refugee self-reliance offers an opportunity to rethink the role of education and the local community as part of the solution to the refugee crisis. In addition, it helps to encourage a broader participation of refugee community, local, and international stakeholders in education at the tertiary level. This dissertation helps to rethink not only calls to action to find solutions to enhance refugee self-reliance but creating conditions to ensure engineering education and refugees can become part of the solution.

2. ENGINEERING DESIGN WITH SYRIAN REFUGEES: LOCALIZED ENGINEERING IN THE AZRAQ REFUGEE CAMP, JORDAN

Freitas, C. C. S., DeBoer, J. (in review). Engineering Design with Syrian Refugees: Localized Engineering in the Azraq Refugee Camp, Jordan.
Target Journal: *Australasian Journal of Engineering Education*

2.1 Abstract

This paper presents the processes from the creation and implementation of an engineering design course in the Azraq refugee camp in Jordan over multiple iterations from 2016 to 2019. This design course used an innovative *localized engineering in displacement* curriculum integrating an active, blended, collaborative, and democratic learning environment. The idea of 'localization' is rooted in the contextualized design address to local assets and presented as capstone projects at the end of the course based on authentic learning, and participatory design. The capstone projects consisted of realistic design solutions to problems that refugees faced in their daily lives. We present findings that include description of the course design, the students' products, as well as the contextual challenges in implementing engineering courses and co-design in refugee camps and the pedagogical response to these challenges. Overall, we describe as a general outcome of our study the novel approach to teaching engineering design for learners in the Azraq refugee camp, which could be applied in other contexts.

Keywords: humanitarian engineering, localized engineering, engineering design process, authentic learning, refugee camp, community development

2.2 Introduction

Refugee education is limited and generally of low quality (Dryden-Peterson, 2011, p.6). In addition, millions of refugee students are often shut out of formal pathways to learning. The United Nations High Commissioner for Refugees (UNHCR) estimates that only 3% of adult refugee learners who are eligible for postsecondary education are able to enroll in higher education programs (UNHCR, 2019g). This lack of successive educational opportunities negatively affects the morale of young refugees (Butler, 2015), and therefore, higher education opportunities need to be considered as both an element of hope and a better life for displaced

learners (Magaziner, 2015; Platzer, 2018). Humanitarian agencies have recognized the value of education to supporting displaced communities and recent efforts have addressed calls to action to foster refugee self-reliance through education (UNHCR, 2019c). Particularly, technical and vocational education and training (TVET) and higher education are considered as forms of education that can be used to foster community integration, reduce inequalities, and lead to durable solutions in crises (Gladwell, Hollow, Robinson, Norman, Bowerman, Mitchell, & Floremont, 2016; Hilal, 2017; Paulson, 2009; Williams, 2018).

However, there are several obstacles to students pursuing TVET and higher education opportunities in displacement, such as accreditation, language, and cost (Gladwell et al., 2016). Therefore, emerging educational programs in displacement need to provide mechanisms to mitigate those obstacles and offer opportunities for local development. Still, the literature focused on engineering design in refugee settings is scarce, and in terms of engineering education in refugee camps, it is virtually non-existent. In light of this need, *Localized Engineering* emerged as a promising alternative to fulfil the HE and TVET needs in displacement. The main objective of the *localized engineering* model is to provide the students with an opportunity to attend an undergraduate introductory engineering course and develop technical and labour-market relevant skills focused on local problems. The program includes a curriculum with technical content in digital videos and formative assessments, professional skills, and engineering design, all focused on needs identified by the local students themselves.

In this work, we explore the creation process and outcomes of this *localized* model that was developed and taught to tertiary learners in the Azraq refugee camp in Jordan from 2017 to 2019. The Azraq camp has been a temporary home for 40,000 Syrians since 2014 (UNHCR, 2019f) and we decided to implement the course in this camp given the established collaboration between our research partners with local agencies in the camp. This opportunity allowed the development of this *localized* model to introduce engineering design in refugee settings focusing on needs identified by the local students themselves using co-design. In addition to describing our *localized* model and presenting the context of education in displacement, we outline in this paper the research design to document the course development process. We also present the four main contextual challenges throughout this process. Then, we present the recommendations for engineering design and co-design in similar contexts. Finally, we discuss our conclusions and next steps.

2.3 Research background

2.3.1 The context of education in displacement

By the end of 2019, the displaced populations reached 70.8 million, with 25.9 million of these individuals being considered refugees (UNHCR, 2019a). Today, the average length of displacement worldwide is approximately 20 years (UNHCR, 2016a). Considering that learners might spend their entire learning pathway throughout primary, secondary, and tertiary education as refugees, developing strategies to ensure access to high-quality education in formal and non-formal settings is more important than ever. However, education gets disrupted in refugee situations, and displaced communities do not have a guaranteed means to access education opportunities without an international and humanitarian intervention (Demirdjian, 2011, p.6). Additionally, creating formal or informal education opportunities in displacement is a challenge in terms of political, economic, and infrastructure types of contextual challenges (Bellino & Hure, 2018; Crea & McFarland, 2015; Dahya & Dryden-Peterson, 2017a; Moser-Mercer et al., 2018; Sheikh et al., 2019).

The complex and unique nature of displaced communities negatively affects the international efforts to meet specific goals and deadlines for education in displacement (Demirdjian, 2011). In addition, the learning process is also challenging in fragile conditions. For example, displaced learners often experience events and traumas that affect their mental health, and continuous exposure to psychosocial, emotional traumas can lead to lifelong impairment of learning health (Shonkoff et al., 2009). Therefore, education in displacements needs to take a humanitarian role by addressing psychosocial support, developing conflict resolution, and leading people towards community reconstruction (Sinclair, 2002).

In the context of refugee education, TVET and HE have been seen as important steps towards refugee self-reliance by providing means to ensure their integration in the economy (Duong & Morgan, 2001; Hilal, 2012; ILO, 2018; Platzer, 2018; Williams, 2018; Wright & Plasterer, 2012). Particularly to engineering education, there are a number of opportunities to use engineering skills to provide labor-market skills in displaced communities and local capacity to tackle local needs. However, solutions to mitigate refugees' technical needs are typically brought in from outside the community, overlooking local expertise. Additionally, there have been

exhaustive debates and criticisms of foreign aid and its failures in development contexts (Park, 2019) where most displaced communities are based.

2.3.2 Defining Localized Engineering

The *localized engineering* model was specifically designed for displaced settings by the instructional team from the Purdue University in 2016. The *localized* model underscores HE and TVET by enabling learners to acquire technical, professional, and design engineering skills to achieve higher education credits through Continuing Education Units from the Purdue at the end of the course. The keystone to the program is our partnership with local learning spaces (usually in-country implementing NGOs) and university partners to invest in long term implementation of solutions in the community. Building on foundational literature from critical pedagogy (Freire, 1970), we propose a model that encompasses the curriculum itself, the collaborative attitudes, the prioritization and centering of local engineers' learning pathways, the pedagogical training and capacity building of local instructors, and the institutional partnerships required to recognize and implement students' work. The *localized* engineering curriculum examines where the local community boundaries are and where the obligation to solve the problem lies. However, in the refugee context, it is challenging to identify what the 'local' includes, given the diffuse political and social scenario. Instructors and students must navigate this by iteratively and collectively defining the different actors along with their cross-collaboration within their local community. Thus, *localized engineering* emerged as a term to synthesize research efforts to advancing praxis for engineering education in displacement in alignment with working standards for good practice in displacement contexts. The idea of 'localization' is rooted in the contextualized design address to local assets and presented as capstone projects at the of the course based on authentic learning, and participatory design. The capstone projects consisted of realistic design solutions to problems that refugees faced in their daily lives.

Course content and structure

The course is structured around four learning objectives: (1) using a systematic problem solving method to identify, evaluate, and define the scope of an engineering problem; (2) applying the engineering design process to generate ideas as well as critically evaluate and develop evidence-based solutions; (3) fostering the growth of reflective individuals and

empowering their social agency; and (4) discussing and practicing professional competencies. Content coverage specific to these learning objectives comprised four main topics: engineering design process (EDP), electrical and electronic systems, programming, and solar energy.

EDP, as taught in the course, covered co-design where students learned the following elements: need finding, problem identification and scoping, concept reduction and selection, evaluation, testing, prototyping, and communication. Through this process, we used co-design to ensure the capstone projects developed in the course take end users seriously as partners in the development process (Sanders & Stappers, 2008) as well as the local actors involved in the process, such as humanitarian agencies, local community, and donors. We also offered specific classes focused on professional development where students learned about teamwork, communication, and feedback. The electronics module included theoretical and hands-on activities in every class session. The entire electrical engineering and electronics module relied on practical application and project-based activities where students learned how to conduct measurements and testing, identify and use engineering tools, demonstrate electronic skills in analogic and digital circuit development. The programming module provided basic programming skills so that students could create and modify the Arduino software depending on the type of sensor used in their specific circuit. Lastly, the solar energy module provided a foundational understanding of solar energy principles as an authentic design problem context. Solar energy is commonly used in the Azraq camp due to the location in the desert, and students showed interest in comprehending and using this technology in the course.

2.3.3 Relating Localized Engineering to Community Development

The critical role of engineering in addressing issues and challenges in humanitarian settings is widely recognized. Engineering practice enables the development of countries and communities (Lucena et al., 2010). Historically, engineering has roots in humanitarian and global development (Jesiek, Borrego, & Beddoes, 2010; Schneider et al., 2008). Further, engineering design has become increasingly prominent in humanitarian literature to discuss the importance of engineering design and community development and, if used thoughtfully, could be a potential tool for shaping the environment and society (Drain, Shekar, & Grigg, 2019; Mattson & Wood, 2014; Mazzurco & Jesiek, 2017; Papanek, 1984; Schneider et al., 2008; Wood & Mattson, 2016).

Also, engineering has been considered as a key player to plan, design, implement and develop solutions to address humanitarian challenges (Dandy et al., 2017).

In the *localized* engineering course, while adopting co-design, students see themselves as important players in conceptualizing these solutions and become social agents developing their communities. In this process, they no longer rely on international aid and they can rethink their perceptions of development towards social justice. The *localized engineering model* seeks to associate engineering design, capacity building, and the knowledge uniquely held by refugee learners to develop their understanding of community needs and feasible solutions.

2.4 Research design

2.4.1 Research questions and study design

In this paper, we address the following research questions:

(1) What are the processes to create and implement an engineering design course in the Azraq refugee camp in Jordan?
(2) What are the contextual challenges in the Azraq camp for creating and delivering this engineering design course?
(3) How do these challenges influence the course implementation and pedagogical response?

Given the complex nature of, and uncertainty in, refugee settings, we decided to use an exploratory case study (Yin, 2014) to collect and analyze the data for this study. By using the case study, it offered flexibility to design our data collection methods and analysis. In this dissertation, we are keen to understand a specific phenomenon (the engineering design course), under a specific context (the Azraq refugee camp), conducted in 2017, 2018, and 2019 as our unit of analysis. This methodology also allowed for the analysis and interpretation of the contextual challenges to creating and delivering the engineering design course. In addition, the case study approach is appropriate given its flexibility to adapt our research design and data collection methods to the complex setting of refugee camps.

2.4.2 Research context: Azraq refugee camp, Jordan

The Azraq camp is located in an empty desert area and 100 km east of Amman (See Figure 11). In Azraq, different humanitarian agencies manage cash assistance, food security, health, protection, water sanitation hygiene, and emergency shelter under the UNHCR umbrella (UNHCR, 2019f). The decision to allocate the camp in the desert was taken by the Jordanian government due to the high forced migration of refugees arriving in Jordan daily (Dalal et al., 2018). Common challenges that affect the Azraq camp are the need for improvements to shelter design to protect people against the harsh desert weather conditions, to water management systems, and to avenues for freedom of movement to leave and access external aid (Al-Bakri et al., 2016; Dalal et al., 2018; Hoffmann, 2017).

Figure 11. Azraq refugee camp

Note. Retrieved from http://tracks.unhcr.org/2015/11/a-teenage-refugee-champions-girls-education/

2.4.3 Course structure and population

The LED course consisted of an engineering design course (Freitas et al., 2018) with a LED curriculum centered around and co-created by displaced tertiary learners to acquire technical, professional, and design engineering skills. The literature on engineering design in refugee settings was scarce, so we had to adapt the existing literature about engineering design more broadly to the specific context of the Azraq camp aligned with our own experience

teaching engineering design in traditional universities and other displaced contexts (Radhakrishnan & DeBoer, 2016). The course included 24 face-to-face sessions (120 minutes in length) and took place over five months in a blended learning environment. This engineering course relied upon the international collaboration between the Purdue University, the University of Geneva, and implementing INGO (international Non-Governmental Organization) partners in the camp. The specific number of learners who participated in the course is presented in Table 5.

Table 5. Course participants in the engineering design course in Azraq

Description	2017	2018	2019
Enrolled students in the Azraq camp	**28**	**14**	**15**
Male	**15**	**12**	**4**
Female	**13**	**2**	**11**
Lowest age	**18**	**18**	**18**
Highest age	**50**	**36**	**44**
Syrian nationality	**ALL**	**ALL**	**ALL**

2.4.4 Data collection

Our team used informed consent for original data from students and facilitators and always maintained their anonymous identity when reporting findings and information about the course. The institutional review was executed through deferral to collaborators at the University of Geneva, who had worked in the context for a longer period of time. The complex nature of the camp also required multiple strategies to collect qualitative data from 2017 to 2019 to mitigate the challenges to systematically collect information due to infrastructure challenges. We conducted a total of 4 semi-structured interviews with representative learners and facilitators from each year. For the semi-structured interviews, we strategically identified and interviewed participants who were actively engaged throughout the course. We also analyzed the videos and images shared throughout each year as part of course assignments and capstone projects, slides and writing reports from final project presentations, conversations from an online forum, entrance exams, weekly surveys, and post-course questionnaires. We analyzed artifacts from participants that either completed or dropped the course. In addition, we analyzed the memos, instructor journals, and observation reports from fieldwork experiences.

2.4.5 Analytic approach

In this dissertation, we conducted data analysis that was both concurrent with and subsequent to the data collection phase. By using an inductive approach (Thomas, 2006) and theoretical process (Braun & Clarke, 2006) for our thematic analysis, we collected the data, analyzed patterns in the data using thematic analysis (Braun & Clarke, 2006), and then reported our findings based on the research questions (Thomas, 2006). The process of coding and thematic analysis was done after data collection and was supported by data triangulation through approaching data with multiple perspectives from researchers and course participants (Denzin, 2015). In the data analysis phase, we looked deeply into personal experiences from course participants to determine what events were contextually relevant to our research questions. Given the large number of data sources collected from 2017 to 2019, the analytical process was divided into different phases. Initially, we conducted open coding to gather and describe the relevant data before importing to NVivo, a qualitative research software package used for data analysis. Then, codes were grouped together and systematically categorized by assigning units of data and codes. We initially started by analyzing the course artifacts such as online conversation, course assignments, weekly surveys, journals, and memos. Then, we used the interview in a second stage to make meaning of our preliminary findings. We discarded codes that did not contribute to answering the research questions. The main researcher in this study used his fieldwork experience, extensive interaction with learners and facilitators and reflections to categorize the data. Then, we systematically used the coding process proposed by Braun and Clarke (2006) to apply thematic analysis and generate significant themes related to our research questions. To help communicate my data analysis, we used data displays such as concept maps and matrix to describe the concepts, data flow, processes to develop the course, and location of the phenomena being analyzed. To provide an additional degree of validity to our findings, we used member checking, audit trail, triangulation, and peer-review across authors and participants in the study during data analysis (Denzin & Lincoln, 2018).

2.4.6 Research considerations with refugees

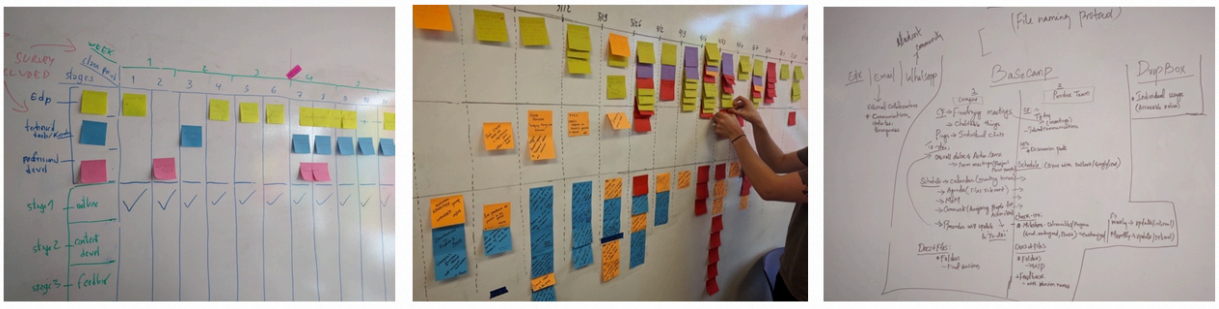
Many complex dimensions can influence the design and development of research in refugee camps; these dimensions include challenges in building trust with the local community,

problems with representativeness, gaining access to the refugee community, limited data collection, psychosocial problems, and economic incentives for the community and research participants (Ellis et al., 2007; Fegert et al., 2018; Fox et al., 2020; Head, 2009; Jacobsen & Landau, 2003; Pittaway et al., 2010). The existing trend in working with members from the community, while meeting some participatory goals, can also create unintended consequences. For example, the participatory approach never includes all sectors in the community, and those who are recruited are often chosen because they were easier to be selected (Temple & Moran, 2006, p. 14). Our team considered these complex dimensions and attempted to balance the numerous demands between research, ethics, and refugee populations to enhance the scientific rigor of this study and meet the goals and protection needs of our collaborators.

2.5 Findings

2.5.1 Course development

This section describes the process of developing and implementing the *localized* course in the Azraq camp. The genesis of the course began over a year before the first course implemented in 2017. We started with collaborative discussions across a multidisciplinary team from the Purdue and international partners with extensive experience in the Azraq camp to understand the specific challenges and potential collaborators in this camp. The instructional team at the Purdue University studied previous literature about refugee education to create an initial course plan that responded to constraints and expectations in the camp (See Figure 12).



(a) (b) (c)

Figure 12. (a) Course schedule process; (b) Analytical process of the course participants' feedback for pedagogical response; (c) Diagram of the multiple digital tools used in running the course, communicating within the instructional team, and course coordination

The contextual understanding of restrictions and limitations in the camp was fundamental in the earlier stages of the course development. For example, planning the course schedule required brainstorming with local collaborators in order to adapt the course to existing holidays, weekends, and national events. In doing so, we could understand when facilitators and other agencies could not open the classroom inside the camp. We also needed to understand how much time per class we had available, infrastructure in the classroom for online learning, and classroom accessibility. In light of this information, we had the chance to adapt the course schedule and increase the flexibility to submit course assignments. Once the course was structured, the next step consisted of coordinating the recruitment and pre-course workshop as the initial phases in the course implementation.

In general, the learning objectives remained the same over the years. However, our pilot course in 2017 (Freitas et al., 2018) revealed challenges that led to course structure changes. For example, some prevailing challenges, also discussed in this work, were limited digital and computer literacy, restrictive policies to work with the local community, and limited regulations to allow students' access to the learning center. We responded to these challenges by restructuring the courses in 2018 and 2019. In this work, we describe the final structure of our course after responding to these challenges.

2.5.2 Course implementation

Student recruitment and pre-course workshop

The recruitment process was coordinated with local partners to disseminate the course callout in the camp through paper-printed flyers. On the flyer, we included information about the minimum criteria to enroll in the course and expected outcomes. The course required students to be 18 years or over, residents in the Azraq camp, understand English, expect to spend at least 4 hours on in-class activities per course week, and attend at least 75% of the classes to receive credit. Given the restrictive policies in Jordan in terms of course accreditation from international programs, the credits received at the end of the course were used to attest the students' skills in order to take advanced course within the camp. After creating a list of potential students interested in the course, the next phase was a pre-course workshop. The pre-course workshop consisted of a three-day on-site session, where we introduced the instructional team. We also

provided an overview of the LED curriculum so that students could get a sense of how and what they would learn in the course (See Figure 13). This workshop also offered an opportunity to help instructors to get familiar with contextual challenges and build social connections with the students and local facilitators. The workshop culminated in an entrance exam where students answered word problems in both English and Arabic, basic logic and math problems, and a motivation statement.

Figure 13. Students discussing the design process during the pre-course workshop

Course delivery

The *localized engineering* model used an integrated framework of active, blended, collaborative, and democratic (ABCD) pedagogies. Throughout the course, students engaged in active learning where they learned by doing (Freeman et al., 2014); flexibility to students' needs and infrastructure limitations by using a blend of online and self-directed activities mediated by local facilitators, printed materials, and face-to-face elements (Garrison & Vaughan, 2007); collaborative learning to foster peer support, codesign, and co-construction of knowledge (Rutherford, 2014); and democratic learning that comprised our engagement with critical pedagogy (Freire, 1970; Wylie, 2014). By engaging in critical pedagogy, we created the opportunity for students and our instructional team to co-create the course and also to support students' individual agency to improve their own conditions. The local facilitators (See Figure 14) recruited in the course in the first cohort (2017) were employees from local agencies with no expertise on the topic taught in the course. In subsequent years (2018 and 2019), we recruited graduates as local facilitators. Facilitators were responsible for providing feedback or reporting issues encountered in the classroom that affected the course progress.

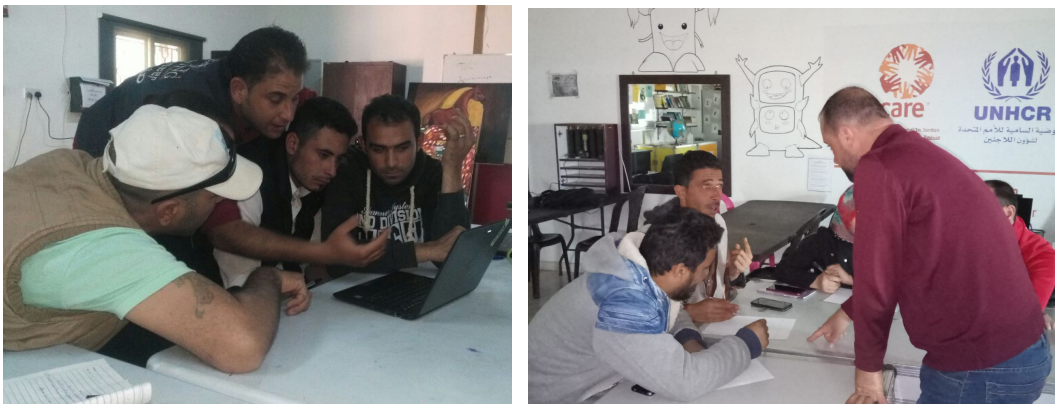


Figure 14. Local facilitator engaging with students during the design process

Capstone projects

The course culminated in multiple capstone projects where students worked in groups of four around common interests using a participatory approach. Through this approach, students engaged with multiple stakeholders – particularly instructors, local agencies, community, and users. This co-design process also helped to bring political and ethical dimensions within their final projects. Additionally, this participatory approach also improved relationships and transparency between different team members and stakeholders and allowed for a richer description of work developed during the final presentation. Students iterated through the multiple engineering design stages to identify needs and problems, create and select concepts, develop prototypes, and perform tests. In the end, students presented their processes and prototypes to a panel of judges composed of engineering experts, international partners, international collaborators, members from implementing organizations, and community members (See Figure 15).

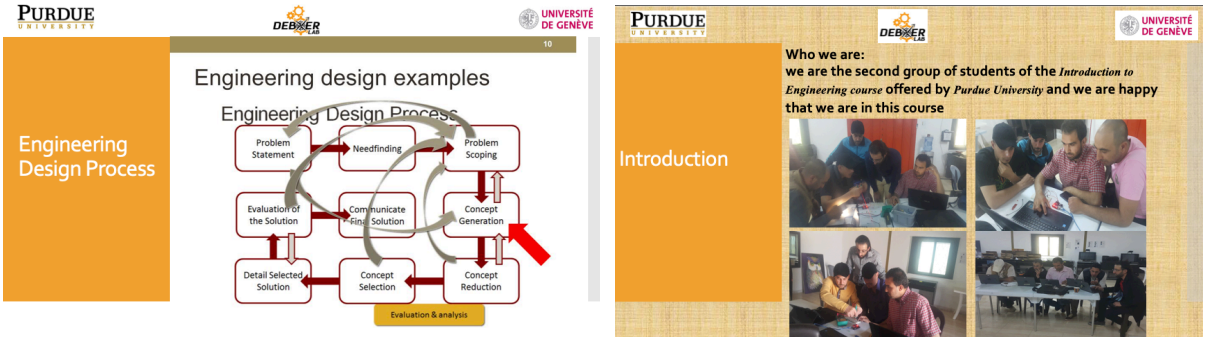


Figure 15. Screenshots of the slides used by one group in the final capstone presentation

The capstone projects were used as a platform to synthesize students' comprehension of theoretical concepts taught in this course and develop practical solutions to community needs in the Azraq camp. Our participatory approach helped students to provide realistic solutions to problems they faced in their daily lives, giving them a sense of ownership and community engagement. At the end of the course, students came up with solutions to problems they themselves identified. Overall, students developed a total of 10 capstones projects over a period of three years of course implementation. We describe below a selection of two example projects created by the students from the first year.

Example 1. Smart trash-collecting truck

In this project, students realized that the waste collection system in the camp was an important social problem. They proposed an intelligent system integrated into the garbage truck to detect distance and to measure the trash level (See Figure 16). They could then inform agencies about waste collection logistics and improve the efficiency of the system in the camp. According to their solution description, 'the idea is to integrate the project into waste sorting, recycling, collection, and sale of recycling plants [*sic*].'

Figure 16. Student creating the garbage truck prototype

Example 2. "Econ pro" – Environmental conservation (*named by students themselves*)

Students used the data collection process learned in the course to examine data about local pollution in the camp. Then, students justified why they selected this problem by saying, 'in the light of these results, and through the engineering training we have acquired, we have begun to address the problem of environmental pollution. We have set out to study a project to supply solar home.' According to the group, they followed the engineering process to scope their alternative design concept (See Figure 17). Briefly, they 'have studied the project of solar home supply and studied the costs of the project and the appropriate angles to be installed panels to

make the best use in the winter. We conducted the study based on the engineering training we received and rel[ied] on real numbers and scientific facts.'

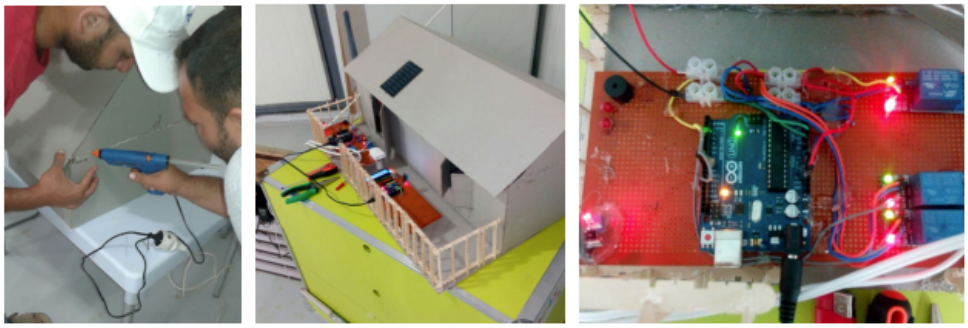


Figure 17. Students creating a solar home prototype designed to simulate a system that uses solar energy to control electric devices in the shelter

2.5.3 Contextual challenges and their influence on course implementation

This section presents themes that resulted from our thematic analysis in terms of the aspects that comprised the course development and pedagogical responses specifics to the context of the study. To identify contextual challenges, we paid particular attention to students' and facilitators' experiences. Some challenges identified in our analysis seemed to have an overlapping impact on the course implementation, as will be demonstrated. Additionally, with respect to the major themes presented below, these findings were corroborated with our observations while visiting the camp. While our data analysis revealed these themes as significant challenges, our observation, positionality, and experience in the field helped to delineate and confirm the impact of these themes in the course development. For example, course participants used the interviews and online forum to talk about the limited course accessibility and our observations helped us to understand to what extent this limitation is related to the context of displacement or challenges with distance learning itself.

Experiencing limited physical and digital course accessibility

The limited course accessibility was one of the most prominent course aspects influenced by contextual challenges which impacted the B "blended" component in the *localized* model. For example, students who had attempted to access the course content from their shelters expressed frustration due to poor internet, lack of electricity, and computer resources. As one student pointed out, 'this week the net was cut for one day. Also, the electricity was cut off in the middle

of the lesson.' The internet and electricity issues occurred very often, and it had a direct impact on decisions that were taken to extend the course length.

From a regulatory standpoint, facilitators reported several instances in which they were told to stop the classroom since the local managers had to leave the camp and close the learning center. Students also were not allowed to stay in the classroom after a certain time or even work from their own shelters due to a lack of equipment, restrictions on equipment being taken out of the hub, and limited freedom to walk in the camp after working hours. In light of these accessibility challenges and pedagogical barriers, we decided to engage with local facilitators by giving them more independence and flexibility to identify the prominent challenges in the course that required attention. Consequently, the facilitators supported the negotiations with local partners to allow more flexibility to access the classroom after the course period based on students' needs. As one student noted, 'only the facilitator can understand that and get some of the solutions for the better of the student and the class.'

Struggling with practical versus theoretical learning in the design process

Our analysis indicated that the more abstract, or what students described as theoretical steps of the engineering design, such as analytical thinking about need-finding, problem identification, and conception evaluation, made students feel frustrated at the beginning of the course. As one facilitator pointed out, 'so far all the classes are theoretical, and I think this maybe make them [students] feel boring or not exactly what they imagined.' Students also reported this opinion regarding the lack of hands-on experience with the electronics tools. For example, as one student noted, 'I attended the first three weeks, and nothing practical happened, I know some friends keep attend in the course and tell me that you are too slow in your course I am sorry but, I got involved into many courses, here I don't excited like those courses.'

From discussion with facilitators before and after each class session the students' frustration with analytical steps of the design process seemed to be consistent. While the participatory approach helped to create a dynamic learning environment, lacking hands-on activities at the beginning of the course disrupted their learning experience and also decreased their motivation to engage in need finding activities and problem solving. However, over time, participants highlighted the importance of having a systematic process and engaging in the design process stages like problem solving. As one student noted, 'At first I hated the lessons of

fixing problems I now understand its importance even more.' Despite efforts from the instructional team to enhance the students' learning experience, facilitators reported that students continued to struggle to ask for help regarding theoretical aspects in the course involving analytical thinking throughout the engineering design process. As one facilitator put it: 'if they [students] have problems, they just leave it. They don't ask about it'.

Lacking community support for local project implementation

Regardless the emphasis in participatory design and community collaboration throughout the course, students surprisingly reported limited support from the local community to support the capstone projects, which according to them, limited their motivation to pursue their goals. According to one student:

> 'Here in our camp, the local community, it divides into two groups, let me say. Some of them, they encourage the students. When they see their prototypes, their work, they get enthusiastic about them, they encourage them. The other group of the local community… They say, 'This is all something. This has nothing to do with the reality. You're just… This is a fantasy and you're just trying to do something that we can't apply here in our community.'

As indicated in the transcript above, the local community failed to acknowledge the value of their ideas and offer support. Additionally, our analysis also indicated a political barrier to advance the capstone projects developed in the course. As one student said, 'sometimes they [local authorities] give you the support, but at the same time, there are some rules or there are some other, let me say, rules that we can't… They would just say, 'It's not allowed to do this. You need to get experience to do this.' And this will make a challenge for us to do. They support you, they go, 'We are with you, but this is not allowed. You need experience to do this,' and I worry. Sometimes, many things we need to do or prepare, we need to get something, a special permit for this, for that, and this is an obstacle for us.' In another example, course participants highlighted

Importantly, as can be seen from the examples in this section, while the co-design was used to integrate learners and multiple stakeholders, it may also indicate an extra level of complexity in this participatory approach. In both of these cases, we see the implicit or hidden

aspects of the participatory process that reveal a challenging interface with and between different actors in refugee settings. Particularly, to effectively transpose projects from the classroom to the local community.

Limited learning pathways and formal education opportunities for advanced studies

Participants not only experienced challenges to implement their projects in the community, but they also were not afforded with alternative options to advance their studies to build off of this course. Due to this restrictive environment to support project development, some students demonstrated frustration and lack of confidence to apply the concepts learned in the course or formally continue their education in other topics. As one student said, 'I am not satisfied with my current reality. When I try to do a plan for help me to change my life, and it fail, I think you can imagine how I feel!?.'

In light of numerous reports from students and facilitators regarding restricted follow-up course options in or near the camp for students, we created a sustained individual program, based on independent projects and entrepreneurial opportunity, by offering funding and technical mentorship to translate their capstones into real-world applications. Additionally, we also provided hardware for students to implement their ideas. Our hardware-driven intervention seemed to have a positive effect, as noted by one of the students, 'before the arrival of the kit you feel concerned about the completion of the project, but after arrival did not remain something I am concerned and allow the completion of the project.'

However, there are also limitations to this form of technology-driven response. Our experience revealed that restrictive political and economic realities on the ground still offer significant barriers when it comes to simply deploy technology solutions in the camp. In addition, the examples showed how participatory design also requires actions to articulate stakeholders to understand the specific needs of engineering education in displacement. Thus, participatory design in engineering programs in displacement can be seen as an invitation to political and government engagement to guarantee means and conditions to advance learning pathways.

2.6 Discussion

The focus of this dissertation was to explore the creation and implementation process of an engineering design course in a Jordanian refugee camp using a *localized engineering* model. Therefore, recommendations and findings may be relevant to tertiary learners in similar contexts where the course is structured around participatory design and community development. Although this was specifically applied in a refugee setting, the lessons learned could benefit A, B, C, or D aspects of a similar course in traditional classrooms. In terms of the impact of our course in the local community, our analysis revealed that our course created an opportunity for students to develop their self-agency. For instance, when we asked a former student to describe the LED course, the learner answered that 'the other students, they just complain about problems and they're waiting for other people to come and solve these problems, while the engineering students, they start about thinking of how we can solve this problem by ourselves, not wait for others to solve for it us.' In another example, when we asked to describe the course to future students, one student pointed out that 'this course is important to those who want to help the community addressing the issues affecting them… so to those who are interested to address the issues affecting the community, this is the best course for them to take.'

The simple act of working together with refugees proved to be an effective way to provide a pedagogical response to local challenges in similar settings. On the other hand, there are significant barriers that still play an important role in displacement. The analysis of the data collected from the participants in the course revealed four main contextual challenges. These were: (1) *experiencing limited physical and digital course accessibility; (2) struggling with practical versus theoretical learning in the design process; (3) lacking community support to local project implementation; and (4) perceiving limited learning pathways and education opportunities for advanced studies*. Based on the lessons learned from this program, particularly the complex nature of challenges that have overlapping implications in the course development, we suggest two main considerations in terms of how to foster co-design in displacement and how to leverage engineering education in refugee contexts.

2.6.1 Fostering co-design and authentic learning in displacement

We have noted how the connected nature between the participatory design and authentic learning has the power to empower refugee students and engage them as local citizens. On the other hand, it is recommended that the instructional team work closely with local partners, such as humanitarian agencies and local partners, to understand the course limitations and contextual challenges before developing engineering programs in displaced settings. Otherwise, such a gap in the course development might lead students to feel frustrated and unmotivated since their projects will not be implemented in the real-world due to political and economic barriers. For instance, if the design course is created to address locally relevant problems, the instructional team might want to contact the local managers and stakeholders to encourage their collaboration not only during the course time period but during the post-course period as well.

Throughout the course, the instructors also should create strategies to carefully observe students' progress and provide different types of pedagogical and motivational support. Particularly, to ensure that students overcome eventual difficulties in the design process due to non-practical and analytical steps in the design process, which may lead to a lack of motivation. This can be addressed by engaging students in dynamic activities to promote collaborative learning during the early stages in the design process. When it comes to digital learning with limited physical presence from the instructor, it is important to provide electronics resources where students can easily and frequently search for information from a reliable and easy source to support independent learning.

2.6.2 Leveraging engineering design in refugee settings

While participatory design implies that multiple stakeholders, local partners, and the community need to be integrated in the design process, we have noted an extra level of challenge in displacement. Thus, we recommend engineering educators to develop a comprehensive understanding of the local regulations and stakeholders in order to effectively expose the relevance of their approach within a complex humanitarian architecture. The results of this study contribute to the scarce literature on engineering design in refugee settings. Although the point of this dissertation is not to be a source for policymakers or humanitarian agencies, our findings benefit the development of community-driven higher education and TVET in refugee settings.

Many refugee students struggle to understand the role of educational programs and their immediate relevance. Therefore, engineering design in refugee contexts has an opportunity to help students develop a comprehensive understanding of their role to advance and support community development.

2.6.3 Limitations

We must acknowledge that the developers of the LED curriculum were a part of our research team during the time of this study. As such, we as researchers, may have been prone to see and acknowledge themes and findings that fit within the broader LED narrative of research-based educational practices in refugee settings. The course language is also a limitation. All course participants in the Azraq camp have Arabic as their native language. Overall, the limitations in this study are mitigated by having native Arabic speakers as part of our research team, keeping records on the research process, data analysis, and problems encountered.

2.7 Conclusion and further studies

In this paper, we presented qualitative findings addressing an important gap in the literature related to engineering design in refugee settings. The use of *localized engineering* to introduce engineering design helps to illustrate important considerations when engineering programs and participatory design are implemented in refugee settings. We documented the processes to create and develop an engineering design course in the Azraq refugee camp. We also reported the prominent challenges and their emergent influence on the course (structure and content, design process, capstone projects, and learning pathways). We also presented implications for engineering education in displacement that emerged from our lessons learned. This research will help educational practitioners involved with participatory design in similar settings to provide effective engineering design programs in similar contexts. However, it is important to highlight that further study is necessary to understand the limitations and benefits of the ABCD components of our framework in similar contexts and how they interplay with contextual challenges. The findings in this paper also help humanitarian agencies to understand the resources needed to use engineering education as an effective response to the refugee crisis.

Acknowledgments

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3. CHAPTER 3: *LOCALIZED ENGINEERING* AND SELF-RELIANCE IN KAKUMA CAMP: IMPLICATIONS FOR TERTIARY EDUCATION IN DISPLACEMENT

Freitas, C. C. S., Olayemi, M., DeBoer, J. (ready to submit). Localized Engineering and Self-Reliance in Kakuma Camp: Implications for Tertiary Education in Displacement.
Target Journal: *International Review of Education - Journal of Lifelong Learning*

Abstract

In light of recent calls from the international community to enhance refugee self-reliance, the desire to break a cycle of dependency between the refugee community and international aid has clearly grown. This study focuses specifically on engineering education as a response for refugee self-reliance by empowering refugees as agents of change in their community through a *localized engineering* model. *Localized engineering* was created as a higher education response to provide high-quality undergraduate education for refugees by focusing on engineering design and community development. The purpose of this qualitative case study is to examine the circumstances and responsive approach surrounding the creation and implementation of *Localized Engineering in Displacement* (LED) in Kakuma refugee camp in Kenya. Observing the course development, the researchers found that *localized engineering*, when co-created with course participants and local partners, is capable of offering an effective model to empower students to become engaged citizens and social agents through engineering education. Another contribution is that our study helps to understand contextual challenges that influence the development of tertiary education and vocational training in displacement. Our study demonstrates a clear mismatch between international goals to foster refugee self-reliance and the significant challenges to accessing tertiary education. In sum, the authors concluded that engineering education works best in refugee camps if course participants actively share course ownership, and local managers provide post-course support to capstone projects.

Keywords: engineering design, localized engineering, Kakuma refugee camp

3.1 Introduction

There are many opportunities to use engineering to improve the living conditions in refugee camps (Franceschi, Rothkop, & Miller, 2014; Lorenz, 2004; Nyoka et al., 2017; Tomaszewski et al., 2016). However, when engineering solutions are implemented in refugee settings, engineering expertise is often brought in from outside the community (DeBoer, Radhakrishnan, & Freitas, under review). These decontextualized approaches yield results that primarily impact the displaced community, but this structure can overlook important local knowledge. As the United Nations, civil society, international organizations, and many other experts seek strategies to enhance refugee self-reliance and ease the pressures on host countries (UNHCR, 2018b), the desire to break the cycle of dependency is a common theme. Engineering education as a specific target for building human capital could play a key, supportive role in humanitarian contexts to enhance self-reliance (Leydens & Lucena, 2017; Schneider et al., 2008). Yet, engineering education with learners in refugee camps is rarely considered in the literature or in the practice of technical, vocational, or higher education. To address this scholarly and practical gap, this article carries out an exploratory case study to examine the development of the *localized engineering* course in Kakuma camp and highlight the contextual challenges experienced by the instructors and learners. The Kakuma refugee camp was established in 1992 in north-eastern Kenya, and it has grown immensely in population over the past two and a half decades. With a population of over 191,500 registered refugees and asylum-seekers (UNHCR, 2019b), the Kakuma camp is one of the world's largest. We decided to implement the course in this camp given the established collaboration between our research partners with local agencies in the camp.

This study examines instructional decisions taken in response to these challenges, as well as the course outcomes and learning experiences of the course participants. In addition, this article demonstrates the importance of directly involving course participants and the local community in the course creation and implementation. In this article, we begin by describing higher education and humanitarian engineering within the refugee context. Next, we outline our *localized engineering* model and its creation and implementation process. Then, we present our research settings and methodology. Lastly, we discuss our analysis before wrapping up the article with our conclusions.

3.2 Background

3.2.1 Understanding the refugee crisis

Millions of people have been displaced from their homes, and refugees make up a significant segment of this population, at nearly 25.9 million people (UNHCR, 2019b). A refugee, according to the refugee convention (UNCHR, 1951), is "someone unable or unwilling to return to their country of origin owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group, or political opinion" (p. 3). Currently, millions of refugees reside within camps (UNHCR, 2017), since camps are often preferred means of containing displaced people by governments and humanitarian actors (Turner, 2016, p.139). Considering that refugee camps are often planned and built under an emergency context, these camps are typically understood and described as places of temporary asylum (Turner, 2016). However, the average time spent by refugees in refugee camps has increased significantly to almost two decades, making a mockery of the so-called temporary function of refugee termed "protracted" by the UN (UNHCR, 2006). The shift in the way refugee camps are viewed requires a similar shift in the way we respond to the crisis. One critical response to the crisis, which has been theorized, researched, and posited to hold long-term benefits for refugees is education (Dryden-Peterson, 2011).

3.2.2 Higher education in refugee settings

There is an emerging body of literature on refugee education, particularly addressed to higher education (HE), reporting challenges with learning pathways, limited resources for connected learning, gender inclusion, and challenges to scale (Crea, 2016a; Negin Dahya & Dryden-Peterson, 2017b; Hatoss & Huijser, 2010; Jabbar & Zaza, 2016; Morrice, 2013; Moser-Mercer et al., 2018). In addition, many obstacles currently serve as barriers to access and quality education, such as accreditation, the language of instruction, and financial cost (Gladwell, Hollow, Robinson, Norman, Bowerman, Mitchell, Floremont, et al., 2016). Particularly in Kenya, higher education faces significant challenges in terms of adult literacy, teacher training, limited infrastructure, and limited funding towards tertiary education (Laura-Ashley Wright & Plasterer, 2010). In light of these challenges, it is essential to investigate the role of HE to

support either professional development as well as self-reliance, and evidence suggests that engineering education offer a significant response to humanitarian crises.

3.2.3 Engineering Education in Humanitarian Development

Engineering has been present in humanitarian action and global development for decades (Jesiek & Beddoes, 2011; Jesiek et al., 2010; Smith et al., 2019). In a recent literature review, Smith et al. (2019) have found that the number of humanitarian programs has been increasing over the last two decades, and they identified 67 university programs worldwide that work towards engineering and human development. But to whom are these programs in service? Often, only the most well-resourced students have good access to these programs. As Riley (2007) pointed out, universities offer a wide number of approaches for global education, such as study abroad and exchange programs, programs for global studies in engineering, courses in sustainable and/or appropriate technology education, and the co-curricular model. On the other hand, it is important to engage the engineering education community to discuss the underlying assumptions that surround the increasing number of global development programs.

According to Riley (2007), these global programs have multiple drawbacks that need to be recognized: for example, study abroad programs poorly emphasize the economic, political, and cultural dynamics; global studies fail in engaging students in critical thinking; technology courses overlook the competition between the needs of the engineering students and the community's needs; and, there is often inefficient allocation of resources to deploy co-curricular models. The purpose of the LED curriculum is to present a shift in focus from the learning outcomes of students in the developed world, lending their expertise to communities to a focus on the learning outcomes of students *in these communities* generating localized solutions.

3.2.4 Localized Engineering: A Pedagogical Model to Foster Self-Reliance in Displacement

The *localized engineering* model was designed for displaced settings by the instructional team from Purdue University in 2016. The *localized* model underscores HE and TVET by enabling learners to acquire technical, professional, and design engineering skills and to achieve higher education credits through Continuing Education Units from the Purdue at the end of the course. The keystone to the program is our partnership with local learning spaces (usually in-

country implementing NGOs) and university partners to invest in long term implementation of solutions in the community. Building on foundational literature from critical pedagogy (Freire, 1970), we propose a model that encompasses the curriculum itself, the collaborative attitudes, the prioritization and centering of local engineers' learning pathways, the pedagogical training and capacity building of local instructors, and the institutional partnerships required to recognize and implement students' work. The *localized* engineering curriculum examines where the local community boundaries are and where the obligation to solve the problem lies.

The *Localized engineering* incorporates aspects of active, blended, collaborative, and democratic learning. Active learning refers to engaging hands-on activities where students do something beyond passive receipt of information (Freeman et al., 2014). Blended learning allows flexibility to students' needs and infrastructure limitations by integrating both online resources, printed materials, and face-to-face interactions where possible (Garrison & Vaughan, 2007). Through collaborative learning, students learn from peers and co-design and co-construct knowledge (Rutherford, 2014). Finally, democratic learning, which is grounded in critical pedagogy (Freire, 1970; Wylie, 2014), works to create a space where teachers and students can exercise their roles as critical change agents in society (Freire, 1970).

The course was structured around four learning objectives: (1) using a systematic problem solving method to identify, evaluate, and define the scope of an engineering problem; (2) applying the engineering design process to generate ideas as well as critically evaluate and develop evidence-based solutions; (3) fostering the growth of reflective individuals and empowering their social agency; and (4) discussing and practicing professional competencies. Content coverage specific to these learning objectives comprised four main topics: engineering design process (EDP), electrical and electronic systems, programming, and solar energy. EDP, as taught in the course, covered co-design where students learned the following elements: need-finding, problem identification and scoping, concept reduction and selection, evaluation, testing, prototyping, and communication. Through this process, we used co-design to ensure the capstone projects developed in the course take end-users seriously as partners in the development process (Sanders & Stappers, 2008) as well as the local actors involved in the process, such as humanitarian agencies, local community, and donors. We also offered specific classes focused on professional development where students learned about teamwork, communication, and feedback. The electronics module included theoretical and hands-on activities in every class

session. The entire electrical engineering and electronics module relied on practical application and project-based activities where students learned how to conduct measurements and testing, identify and use engineering tools, demonstrate electronic skills in analogic and digital circuit development. The programming module provided basic programming skills so that students could create and modify the Arduino software depending on the type of sensor used in their specific circuit. Lastly, the solar energy module provided a foundational understanding of solar energy principles as an authentic design problem context. Solar energy is commonly used in refugee settings due to the remote location, and students showed interest in comprehending and using this technology in the course.

Planning and Development Process

The *localized* engineering was implemented before Kakuma in a different refugee camp in Jordan (Freitas et al., 2018). Through this pilot project in a Jordanian camp we learned the best approach to structure the course in subsequent years. In this paper, we describe the overall *localized* engineering model after implementing the necessary changes and our experiences throughout this process. The early stages of our course planning and development process started by engaging local partners throughout the recruitment process to disseminate the course callout, recruitment process, pre-course workshop, and entrance exam. International partners and local managers led the recruitment process due to their deep understanding of the local constraints, such as limited transportation, lack of communication resources, and language proficiency. We disseminated the course callout through flyers, phone calls, and other informal channels. We reduced the minimum criteria to attend the course in order to increase the opportunity to access the LED course for refugees in Kakuma. The course required students to be 18 years or over, understand English, expect to spend at least 4 hours of in-class activities per course week, and attend at least 75% of the classes to receive full credit. Given the restrictive policies in Kenya in terms of course accreditation from international programs, the credits received at the end of the course were used to attest the students' skills in order to take advanced courses within the camp.

Once we collected the name and contact information from the learners interested in the course, they were invited to attend a pre-course workshop. This workshop consisted of a field visit from the instructional team and three days of classroom sessions, and we covered the cost of the provisions of food and transportation for the participants during the workshop. This

workshop played a significant role in the course development due to a number of reasons. Firstly, it was a chance to physically visit the classroom settings, connect with future students and local partners, and discuss course policies as part of our co-creation framework. In this workshop, our past experience showed the importance to discuss with participants what could be the biggest challenges to attend the course so that we could discuss potential solutions together. In addition, we used this in-person opportunity to discuss and agree upon the course attendance expectations, late submission penalty, and course space management. The workshop culminated in an entrance exam that included questions strategically designed to assess and adjust the content, assessment, and pedagogy in the course. Through this entrance exam, we examined English proficiency, critical and analytical thinking, mathematical literacy, motivation, and time/day availability throughout the week to attend the course. The local facilitators participated in our decisions to select the learners.

Course delivery and implementation

The first day of class was decided and coordinated between students, local facilitators, and local partners. In terms of course material, the course slides, assignments, videos, and simulations, were uploaded in advance in an online platform called edX Edge, where students could access the course content. Once we scheduled the course dates, the next step was creating an online forum using a free communication tool called WhatsApp. Classroom sessions occurred twice a week on average in 2018 and 2019, and local facilitators were in charge of setting up the computers, electronic tools (if necessary), and registered the course attendance. However, the facilitators were not only responsible for providing logistics support. Facilitators also were significant by supporting the course co-construction, managing the contextual challenges, translating the content in local language for the learners, and improving the learning opportunities of the learners. In every classroom session, online instructors were available online to support facilitators and students in case of any course-related question or technical problems. For four months, students engaged in a blended course where they learned the different stages of the engineering design process, electronics, programming, and basic concepts of solar energy. At the end of the course, students presented a capstone project.

The course culminated in multiple capstone projects where students worked in groups of four around common interests using a participatory approach. Through this approach, students

engaged with multiple stakeholders – particularly instructors, local agencies, community, and users. This co-design process also helped to bring political and ethical dimensions within their final projects. Additionally, this participatory approach also improved relationships and transparency between different team members and stakeholders and allowed for a richer description of work developed during the final presentation. Students iterated through the multiple engineering design stages to identify needs and problems, create and select concepts, develop prototypes, and perform tests. In the end, students presented their processes and prototypes to a panel of judges composed of engineering experts, international partners, international collaborators, members from implementing organizations, and community members.

The independent projects emerged as a post-course initiative to advance capstone projects (See in Appendix O). Independent projects consisted of a self-directed learning experience where learners received technical support via constructive feedback; however, they had to coordinate all steps by themselves to turn the idea into a real product. To be selected, students were invited to submit a project proposal where they had to meet some requirements, such as team organization, specific files describing the project, professional formatting, and clear specifications addressing the user desirability, economic viability, implementation viability, technical feasibility, and sustainability (see Appendix N).

3.3 Research Methodology

Given the complex nature of, and uncertainty in, refugee settings, we decided to use an exploratory case study (Yin, 2014) to collect and analyze the data for this study. By using case study, it offered flexibility to design our data collection methods and analysis. In this paper, we addressed the following research questions:

- What are the contextual challenges and mediating factors surrounding the creation and implementation of the *localized engineering* course in Kakuma refugee camp?
- How do students and facilitators experience the course?

3.3.1 Research Context: Kakuma refugee camp

The Kakuma refugee camp was established in 1992 in north-eastern Kenya, and it has grown immensely in population over the past two and a half decades. Refugees in Kakuma experience many challenges, ranging from differing forms of insecurity (Crisp, 1999), lack of access to improved sanitation (Nyoka et al., 2017), harsh environment (Bartolomei et al., 2003), poor education quality (Mareng, 2010), and political restrictions. Added to these challenges, Horn (2010) pointed out that restrictions for employment make refugees almost totally dependent on humanitarian agencies to provide for their basic needs (p. 162). The Kakuma refugee camp population consists of people from Somalia, Uganda, Sudan, South Sudan, Burundi, Democratic Republic of Congo, Eritrea, and other countries in the region (UNHCR, 2018a). In Kakuma, it is common for a refugee to be able to speak Kiswahili, French, and in some cases, a third language in addition to English.

3.3.2 Course Structure and Population

The literature on engineering design in refugee settings was scarce, so we used the lessons learned from our pilot course in the Azraq refugee camp in Jordan implemented in 2017 (Freitas et al., 2018). We also aligned the course structure with our own experience teaching engineering design in traditional universities and other displaced contexts (Radhakrishnan & DeBoer, 2016). The course included 24 face-to-face sessions (120 minutes in length) and took place over five months in a blended learning and self-directed learning mediated by local facilitators. This engineering course relied upon the international collaboration between the Purdue University, the University of Geneva, and implementing INGO (International Non-Governmental Organization) partners in the camp. Then, we launched the course in 2018 and facilitated a second course in 2019. The data analyzed in this study came from the 2018 and 2019 Kakuma classes. From a pool of 50 interested applications in 2018, 20 students were admitted to the course. In the following year, 2019, the course also admitted 20 students.

The recruitment process of these students was coordinated with local partners by disseminating the course callout (See Appendix M) in the camp through paper-printed flyers. On the flyer, we included information about the minimum criteria to enroll in the course and expected outcomes. After creating a list of potential students interested in the course, the next

phase was a pre-course workshop. The pre-course workshop consisted of a three-day on-site session, where we introduced the instructional team. We also provided an overview of the LED curriculum so that students could get a sense of how and what they would learn in the course. This workshop also offered an opportunity to help instructors to get familiar with contextual challenges and build social connections with the students and local facilitators. In our course, the local facilitators recruited in the course in the first cohort (2018) were employees from local agencies with no expertise on the topic taught in the course. In the subsequent year (2019), we recruited graduates as local facilitators. Facilitators were not only responsible for providing feedback or reporting issues encountered in the classroom. Facilitators also were significant by supporting the course co-construction, managing the contextual challenges, translating the content in local language for the learners, and improving the learning opportunities of the learners. The workshop culminated in an entrance exam where students answered word problems in both English and French, basic logic and math problems, and a motivation statement. The specific number of learners who participated in the course is presented in Table 6.

Table 6. Course participants in the engineering design course in Kakum

Description	2018	2019
Enrolled students in Kakuma camp	**20**	**20**
Male	**16**	**19**
Female	**4**	**1**
Lowest age	**19**	**18**
Highest age	**44**	**32**

3.3.3 Data collection

The complex nature of the camp also required multiple strategies to collect data from 2018 to 2019 to mitigate the challenges to systematically collect information due to infrastructure challenges. We analyzed data collected over two years of classes that comprised videos and images shared throughout the course as part of course assignments and capstone projects, slides and writing reports from final project presentations, conversations from an online forum, entrance exam, weekly surveys, and post-course questionnaire. For the semi-structured interviews (see Appendix G), we strategically identified and interviewed participants who were actively engaged throughout the course. From this subset of students, we selected five participants from Kakuma. The interview protocols for students and facilitators contained 21

open-ended questions and generally took from 40 to 130 minutes by phone. Interviews were recorded and transcribed. The interviews were structured around participants' experience in the course, motivations, and their process to work on capstone projects. The online conversations and student artifacts were translated from French to English when necessary. In addition, we analyzed the memos, instructor journals, and observation reports from fieldwork experiences.

Ethical Considerations in Research with Refugees

From a practical point of view, many factors can influence the design and development of research in refugee camps – long term relationship with local community, ethics-in-practice, problems with representativeness, gaining access to the refugee community, limited data collection, psychosocial problems, and economic incentives for the community and research participants (Ellis et al., 2007; Fegert et al., 2018; Fox et al., 2020; Head, 2009; Jacobsen & Landau, 2003; Pittaway et al., 2010). In line with recommendations from Mackenzie and colleagues (2007) for researchers to go above and beyond the call to "do no harm," we strove to go beyond basic requirements. First, we sought to obtain "genuine informed consent." Our definition of the term is consent, which is based on participants' proper understanding of their autonomy, and with it, the agency to participate in the course without necessarily agreeing to participate in the research study. Based on our IRB protocol, in order for students to participate in the study, our team issued informed consent forms which were read and signed by all research participants after they communicated their understanding of the fact that their participation in the course was not dependent on their participation in the research study. All prescribed requirements from the institutional review were executed through deferral to collaborators at the University of Geneva, who had worked in the context for a longer period of time. Identifiable data were anonymized in order to maintain participants' confidentiality.

Data analysis

In this dissertation, we conducted data analysis by using an inductive approach (Thomas, 2006) and theoretical process for our thematic analysis (Braun & Clarke, 2006). The data analysis had three phases. The first phase provided an in-depth look into our data sources without interviews at this point. This included a look at the facilitators, learners, and online instructors'

experiences of the creation and implementation of the course. During this first phase, we had the opportunity to build an overall understanding of the data to determine what events were contextually relevant to our research questions. Then, codes were grouped together and systematically categorized by assigning units of data and codes. The phase two consisted of looking at our specific research questions and triangulating it with our findings from phase one until achieving data saturation. We discarded codes that did not contribute to answering the research questions. The main researcher in this study used his fieldwork experience, extensive interaction with learners and facilitators, and reflections to categorize the data. In phase three, we systematically used the coding process proposed by Braun and Clarke (2006) to apply thematic analysis and generate significant themes related to our research questions. In this third phase, we used the interviews to make meaning and triangulate our preliminary findings. To help communicate our data analysis, we used data displays, such as concept maps and matrix to describe the concepts, data flow, processes to develop the course, and location of the phenomena being analyzed. To provide an additional degree of validity to our findings, we used member checking, audit trail, triangulation, and peer-review across authors and participants in the study during data analysis (Denzin & Lincoln, 2018).

3.4 Results and Discussion

3.4.1 Contextual Challenges in Kakuma

In this section, we describe the contextual challenges experienced during the course development in 2018 and 2019, as described in Table 7. In this table, the challenges were divided into two categories: barriers from displacement and limited computer literacy and English proficiency. Additionally, we also use research evidence to point out participants' experiences that led to these challenges and highlight their own experiences. With respect to these challenges, it is important to point out these themes were corroborated with our observations while visiting the camp and previous experience in the Azraq refugee camp. While our data analysis revealed these themes as significant contextual challenges, our observation, positionality, and experience in the field helped to delineate and confirm the impact of these themes in the course development. For example, course participants used the interviews and online forum to talk about the challenges they faced in the course and our observations helped us to understand to

what extent these challenges could be connected to the context of displacement or challenges with connected learning.

Our use of the term "barriers from displacement" refers to challenges that intersect with economic constraints, restrictive policies, and psychosocial traumas intrinsically connected to Kakuma. Our use of the term "limited computer literacy and English proficiency" refers to the learning barriers in displacement. For example, displaced learners often experience events and traumas that affect their mental health, and continuous exposure to psychosocial, emotional traumas can lead to lifelong impairment of learning health (Shonkoff et al., 2009). Thus, understanding the cognitive limitations of students in learning disciplines like the second language (Schoonen et al., 2003) and technological activity (Johnson, 1992) and how it interplays with emotional and physical overload is fundamental to enhance the learning experience. The high-level descriptions that emerged from our thematic analysis are associated with each one of these categories.

First, here we find the high-level descriptions in relation to the barriers from displacement. As our data pointed out, students and facilitators emphasized challenges to access the learning center after class period and reported limited resources and infrastructure to access the course content from their shelter or elsewhere. As one student pointed out, 'learning space allocated is small it's really difficult to connect with other peers because we are divided in two groups and we only meet once a discussion session'. They also showed concern about the opportunities to move forward with their capstone projects due to lack of economic and political support. As one student noted, 'I feel like, when we get our project to the final step and finish the final design *it* did not get applied to real life. They [local agencies] are not interested in implementing our projects the reason is no support because of the final support and the restrictions on us form the local authorities.' Learners also pointed out psychosocial traumas that were often associated with concerns for their families and resulted in lack of motivation. For example, when asked about the biggest challenges in the course, one student said, 'It requires some of sacrifice, for me when i started this course, i left everything behind so as to understand it deeper cuz [sic] when sometimes i used to interfere with my own things'. In addition, a lack of local teaching capacity and higher expectations in terms of what local facilitators can do to support students were often cited as challenges and reasons for facilitators' dissatisfaction. As one facilitator pointed out, they felt pressure to some degree because 'they [students] forgot that I

[as facilitator] just took the course. I'm not an expert on that field for the questions that they're asking me.'

Evidence also presented challenges with language and digital literacy. Language issues were observed among course participants with limited English proficiency. Some common threads highlighted by the participants included problems in communicating with peers and instructors via online forum or even understanding the course material. As one student in Kakuma noted, 'can the videos be translated in French please? My English level is very low/down to most of expression pronounced [sic]. You will excuse me for desturbing [sic] and am very sorry please.' The language issue also related to barriers with second language learning which is explained by the cognitive load theory as intense cognitive processing during the act of mentally shifting between languages (Schoonen et al., 2003). Digital literacy went along with the basic computer proficiency to perform basic tasks, such as installing software and handling word processing tools as well as using internet-based platforms. Situating these challenges within displacement indeed enriches the meaning of our themes. For instance, it allowed us to conceptualize language issues and digital literacy as challenges that resulted from education disruption due to conflict and lack of opportunities to develop these skills in the camp.

Table 7. Contextual Challenges for a Localized Engineering HE Course in Kakuma Camp

Type of Challenge	Themes	Examples
Barriers from displacement	Limited access to the learning materials and learning center	"I just came from the hub but it's not open and this is the time we agreed yesterday. Could u please try [to contact the facilitator] if he can manage getting to the hub" (Student)
	Limited pathways to develop capstone projects after the course	"I mean everything is happening in rush, to me...I would be lying should I say I have achieved my objectives... This wind project is not enough to me...I wanted more but time is not allowing us... I would want to do something after [the] group's project" (Student)

	Emotional challenges	"Here in the camp I live with my brother who [is] suffering from diabetes he can't do anything and apart from that my mother and I have no job or business to earn something …. sometimes I feel like I am going crazy 'cuz no life without education and the duty of family is on my hand… I could do my independent project but I [feel] stuck 'cuz I carry a lot in my head." (Student)
	Lack of certified professionals to coordinate the course and support local training	"I am not a professional, I am not a professional on this, and I had to guide two men at the level that I was in, not just expert but what I got" (Facilitator)
	Inadequate (*electricity, transportation, and the internet, and weather*) infrastructure	"At the moment, it is heavily raining. Students won't manage to reach the center. Yeah, even our colleague who should open the hub was blocked in the other side of the river due to floods. No way to make it today." (Facilitator)
Limited computer and language literacy	Language	"course contents are only in English but there are French speakers too though we have onsite facilitators to explain more but better understanding comes from the videos we watch and the notes we read" (Student)
	Digital and computer literacy	"I'm working with them. Actually, we lost the file in the computer while editing it... We tried to retrieve it, but we couldn't find it, so we'll have [to] rewrite it tomorrow.... Once we able to complete that I'll then get to something outside the group..." (Student)

3.4.2 Course Adaptiveness to Contextual Challenges

While identifying contextual challenges is important, responding to these is equally important. Here, we present the six responsive approaches emerged from perceptions and experiences of course participants.

Fostering a sense of course ownership shared with facilitators

As mentioned earlier, what is at the heart of *localized engineering* is fostering a sense of self-reliance through engineering education. Course ownership and social agency are among the primary factors in our pedagogy to foster refugee self-reliance. We found that the course

facilitators often reported these empowering experiences. In our course, the local facilitators recruited in the course in the first cohort (2018) were employees from local agencies with no expertise on the topic taught in the course. In the subsequent year (2019), we recruited graduates as local facilitators. The following excerpts captured examples of the component of course ownership by local facilitators to support classes. As one facilitator noted, 'I have to go by all means so that I make sure they [students] understand what they're doing, and I think, this was, as a facilitator, my responsibility.' This sense of ownership helped facilitators feel more independent and motivated to achieve the course objectives. Facilitators also engaged in participatory learning by actively helping students in the learning process instead of being mere logistic supports. One facilitator mentioned that 'we [facilitators] are not there to show someone what's supposed to be done, but to guide them over the thing that may help for the design' and, 'we had to take a lot of time to go [understand the material] before the students, they start the class, so that they can learn and understand the topic and what they are going to do. Very rewarding that when they ask a question, I can be able to help them or guide them where they [feel] stuck.'

Reinforcing psychosocial support associated with sense of empowerment

Learners and facilitators often used the terms "community," "change," and "solving problems" to describe the course outcomes. Creating a sense of empowerment and self-agency showed to be a meaningful approach to help course participants to navigate through a challenging reality in the camp. The social empowerment emphasis offered a transformative experience as revealed by the course participants. For example, participants described that this course differed from other educational opportunities in the camp because the course helped them to solve local problems with local resources. As one student pointed out, 'this is the only course that the students take very serious[ly] - the only course [that] came back to change the lives of the people in the government.' The data analysis also revealed a transformative experience that helped students to become social agents. Overall, students perceived the course as a unique experience that empowered their self-reliance. As one student noted, 'when it comes to other education provided in the camp, you learn and expect to be employed but with engineering with skills, you can apply them without being... So you can be self-employed.'

Supporting local facilitators with online presence and teaching preparation

Course participants reported challenges related to "teaching capacity," "support from online instructors," and "content expertise." Our past experience in different displaced settings showed that facilitators take many roles in the course, and they need to navigate throughout many challenges that go beyond logistical support. Facilitators also need to have access to appropriate training given the number of pedagogical socio-cultural challenges they face throughout the course. As one facilitator noted, 'they [students] forgot that I just took the course. I'm not an expert on that field for the questions that they're asking me.' This quote reflects the facilitator's condition as someone that is not a content expert in engineering, and the facilitators still required support from online instructors to address questions raised in the classroom. Thus, online instructors (the international part of the instructional team, based in the USA) were also engaged online and created open channels to talk to students directly, since it helped to minimize the workload on local facilitators. However, we also expanded our support by providing certified training to facilitators to teach them how to deal with local conflicts, support students to engage in self-learning and foster a sense of collaboration and cooperation in the classroom. This pedagogical support to facilitators helped to sustain a learning environment where students and facilitators could rely on themselves over time.

Allowing flexible course agenda and out-of-class individual support

In spite of the collaboration with local partners, the LED experienced a number of challenges in terms of restrictive policies to access the learning hub and transportation issues. Another challenge was that local facilitators struggled to address technical questions given a lack of content expertise. As a result, the instructional team created a number of strategies to address these challenges. For example, we tried increasing the length of time spent in class, creating office hours to support students after class, and creating new assessment strategies. The office hours consisted of specific time slots where instructors were available online mostly on the weekends to support students in any specific issues or questions that they could have. In terms of adaptive assessment, adopting new digital tools, such as Google Docs, helped to simplify the deliverables and feedback received throughout the course. Our analysis indicated that course participants recognized the adaptive processes that occurred throughout the LED course. As one

student noted, ‘introduction to google docs was a big step farther; I liked this idea...now students get feedback easily.’ This strategy emerged as a need to simplify the processes to open new files and keep track of what students worked on throughout the course. Online engagement also led to many positive impacts in terms of communication and psychosocial support. As students pointed out, online engagement enabled ‘easy communication in real-time’ and online communication ‘contains more than you think about it.’

Promoting students’ transitions to self-reliance through independent projects

Students frequently referenced local barriers that hindered their capstone projects. As one student pointed out, ‘when you want to implement something in terms of development, maybe you need to meet with the local authorities so that at least you may have the permission for you to do what you want to do.’ Another student said that ‘sometimes I feel like we all have projects to learn but at a point when you want to study, we may not have the support so, we may not have the funding. So, you just tend to leave your projects to lie down.’ These notes were especially important when students were asked about the next steps after completing their capstone projects. When asked about the opportunities and applications in the community, the students raised feelings of frustration due to limited opportunities to receive support to develop their projects. Course participants seemed to be aware of these challenges, and facilitators reported significant concerns with the next steps after the course. For example, as one facilitator said, ‘the students that will finish, they are not doing anything, and they get an engineering skill they have, but they need to use the engineering skills to turn their life. They cannot be able to do their life ... I don't think the guys that are growing in the community [can’t] do that; they can only do it in school.’

As restrictive policies and economic barriers are described by the course participants, solid channels are important to promote students’ transitions from ideas developed in the classroom to local community. Such long-term need led to the development of entrepreneurial independent projects, which students could pursue after the class. This was an opportunity for them to take their individual prototypes and implement them in their homes and in public spaces for the community; and they were supported in taking their prototypes to implementation. For instance, an example of sustained individual impact is a small-scale wind power generation created by a team in Kakuma. Basically, they came up with the need during the early stages in

the course, listed the specifications and design throughout the course, collaborated with local partners to set up the installation of the prototype, and received the investment from our team to deploy their project in the camp.

3.5 Conclusion

It is not entirely surprising, as the contextual challenges that emerged as themes in our study clearly align with broader literature in refugee education (Negin Dahya & Dryden-Peterson, 2017b; Horn, 2010a; Mareng, 2010; Wright & Plasterer, 2012). However, our localized model embraced those challenges by offering different approaches to respond and mitigate them. Our analysis indicated that the *localized engineering* model offered an effective model to empower students to become engaged citizens and social agents. The findings demonstrated that *localized engineering* underscore political, economic, and psychosocial elements in displacement through engineering education. The political element is reflected in how we involve local partners and communities within the course implementation. The economic element is reflected in how we provide resources to equip the classroom with teaching tools and support independent projects. Finally, the psychosocial element intersects with a sense of empowerment and self-agency.

Our findings have important implications for humanitarian actors in terms of which contextual challenges require attention before deploying engineering and technical courses in refugee camps. This article also points out how engineering education may be helpful in fostering refugee self-reliance. As engineering programs focused on humanitarian development have been increasing over the last decades, finding ways to integrate the local community and local resources as part of this trend requires significant attention. By bridging engineering design and community development in refugee camps, we also hope to inform better practices and ways to respond to local challenges in displaced settings. Overall, the *localized engineering* model was well-received and accepted by course participants; however, the limited learning pathways and restrictive policies presented a challenge for many students. These two aspects need to be discussed and reconsidered to enhance course outcomes. The course participants' experiences challenge the global trend to foster refugee self-reliance. Our findings are revealing a number of challenges encountered by refugees as they attempt to access tertiary opportunies and advance their educational opportunities and entrepreneurship pathways.

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4. UNDERSTANDING ENGINEERING EDUCATION IN REFUGEE CAMPS: A COMPARATIVE CASE STUDY OF LOCALIZED ENGINEERING IN TWO REFUGEE CAMPS

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Target Journal: *Comparative Education Review*

4.1 Abstract

Refugee education is discussed by international and humanitarian agencies as a fundamental action to help refugees to rebuild their lives. Given the recent calls to ease pressure on hosting countries and foster refugee self-reliance, an increasing number of policy makers have proposed the expansion of higher education (HE) and technical, vocational education and training (TVET) for refugees. This article seeks to contribute to the ongoing discourse towards this humanitarian crisis by examining the practice of HE and TVET in displacement through engineering education. Building on a tertiary-level engineering course called *Localized Engineering in Displacement (LED)*, this article examines the degree to which displacement settings influenced the creation and implementation of LED in Kenyan and Jordanian refugee camps through a comparative case study. We applied a Global Framework for Refugee Framework (GFRE) to situate our findings within an existing policy arena by identifying key actors acting with refugee education. The research team also examined the findings and outcomes across Jordanian and Kenyan contexts. Based on the evidence analyzed, we argue that there is a misalignment between international goals and the reality on the ground. In this article, we propose a framework that provides a baseline for different actors to address the contextual challenges that yielded this misalignment. The implications of the research underscore the complexities surrounding HE and TVET opportunities for refugee learners and it affirms the potential role of engineering education in fostering refugee self-reliance.

4.2 Introduction

This article seeks to contribute to the growing discussion towards refugee education as a response to an unprecedented displacement crisis that impact nearly 25.9 million of refugees worldwide (UNHCR, 2019b). Particularly, our approach emphasizes the practice of HE and TVET in displacement. However, the definition of displacement is multifaceted and often misaligned with the current state and context of displaced populations (Hyndman, 2010). Hence, this study uses the term "displacement" as a reference for refugee camps, which is the context of our study. Refugee camps are a preferred means of containing displaced people by governments and humanitarian agencies (Turner, 2016, p.139). In addition, camps are also perceived as spaces that exclude the displaced populations from national laws and regulations addressed to hosting communities (Oesch, 2017). On the other hand, the context surrounding refugee camps is complex. Some authors argued that refugee camps have such a complex nature that refugee communities should be considered from a different socio-political perspective. For instance, Fajth, Bilgili, Loschmann, & Siegel (2019) examined the role of refugee communities living in settlements within host communities, and they argued that refugees and host communities could build close social relations and sustain a peaceful and inclusive social environment (p.17). The literature also suggests that integrating refugees with local economies also opens opportunities to enhance host country economies (Alloush, Taylor, Gupta, Rojas Valdes, & Gonzalez-Estrada, 2017).

Considering that the duration of exile in refugee communities continue to grow to more than two decades (UNHCR, 2016a), it has been argued that refugees require more durable and sustainable solutions. Thus, education has become a key concept proposed to address to foster refugee self-reliance (Aleinikoff, 2015; UNHCR, 2005). However, despite the increasing efforts from the international community to promote refugee self-reliance, recent studies indicate a lack of conditions to achieve this goal, such as restrictive policies and significant obstacles to support refugees' social and economic ability (Easton-Calabria & Omata, 2018). For example, while HE is perceived as a strategic response to humanitarian challenges by supporting refugees to rebuild lives and communities (Gladwell, Hollow, Robinson, Norman, Bowerman, Mitchell, Floremont, et al., 2016), young refugees are often shut out of formal pathways to learning. UNHCR estimates that, of the adult refugee learners who are eligible for postsecondary education, only 3% are able to enroll in higher education programs (UNHCR, 2019).

One of the strongest criticisms of refugee education emerged from the fact that refugee communities lack appropriate infrastructure and political regulations to enable formal and informal learning pathways (Aguilar & Retamal, 2009; Crea, 2016b; Crea & McFarland, 2015; Gross & Davies, 2015; Mareng, 2010). In light of this reality about refugee education, Platzer (2018) suggested that neither the United Nations nor member states provide the necessary conditions to foster access to tertiary education for refugees. Similarly, TVET is also discussed as a form of education that can be used to foster community integration (Paulson, 2009), reduce inequalities (Hilal, 2017), and provide workplace-relevant training (Roche, 2017). However, while TVET is considered an important component to encourage the development of both refugee populations (Williams, 2018), the economic and political resources allocated to TVET has also been widely critiqued.

This article has two goals. First, it seeks to examine the challenges experienced by the research team during the creation and implementation of a tertiary-level engineering course called *Localized Engineering in Displacement (LED)* in two refugee camps. Second, it presents a framework to inform policymakers on how to advance engineering education in displacement. The LED consists of a pedagogical model theoretically informed to advance self-reliance in displacement through engineering education, as demonstrated through research evidence. We adopted a qualitative approach to critically examine the processes of developing and implementing the LED course in two refugee camps, the Azraq and Kakuma camps. In this study, Azraq and Kakuma represented two refugee camps with two distinct contexts. For example, Azraq was launched in 2014 by the Jordanian government to be a well-planned, safe, and role model camp to support the mass displacement of Syrians (Hoffmann, 2017; The Jordan Times, 2014). On the other hand, Kakuma camp was launched in 1992 as a temporary place to support 20,000 minors from South Sudan, and subsequently became a long-term destination for refugees from neighboring countries, such as South Sudan, Somalia, Ethiopia, Eritrea, Burundi and the Democratic Republic of Congo (Gitau, 2018; UNHCR, 2018a).

Our analysis draws on the Global Framework for Refugee Education (GFRE). We used the GFRE because this compact is part of "a unique opportunity to improve the situation for refugees around the world" (IFRC, 2017, p. 1) as it expresses a historic international engagement to support and protect displaced communities (UNHCR, 2018b). At a methodological level, data analysis was based on the Bartlett & Vavrus (2017) process of a comparative case study (CSS),

which envisioned a cross-case comparison as a horizontal look that contrasts one case with another by tracing social actors and other influences along with a vertical comparison built from international to national to regional and local scales (p. 14). This study uses a comparative case study to underscore the complexity of course development and implementation in two diverse camp settings and critique simplistic solutions. We seek to foster a debate about the challenges that influence the development of HE and TVET programs in refugee camps. We also seek to recommend how different actors can realistically collaborate to advance refugee education, particularly, engineering education.

4.2.1 The Value of Education for Refugee Self-Reliance

Education in displacement acts as a source of psychosocial support, develops conflict resolution, and leads people towards reconstruction, social, and economic development (Sinclair, 2002). In academic literature, the intersection between education and self-reliance has been extensively described as a means to foster independence and citizenship (Mosha, 1990; Nyerere, 1972), autonomy through critical thinking (Cuypers, 2004; Kamii, 1991), and humanitarian engineering (Amadei & Wallace, 2009; Mitcham & Munoz, 2010; Schneider et al., 2008). However, while the prevailing opinion among international agencies and researchers has been that education stands out as an important factor to promote stability and self-reliance in refugee camps (Akesson, 2015; Alzaroo & Hunt, 2003; Mayuran, 2017; Winthrop & Matsui, 2013), this notion has been called into question. Recent evidence suggests that lack of infrastructure, limited learning pathways, restrictive policies and regulations, and lack of resources still drastically limit effective education initiatives in refugee contexts (Crea, 2016b; Dahya, 2016; Gladwell, Hollow, Robinson, Norman, Bowerman, Mitchell, & Floremont, 2016). Following the international agenda to mitigate these challenges and advance refugee education, the Global Framework for Refugee Education (GFRE) emerged as a response to achieve this goal.

4.2.2 Understanding the Global Framework for Refugee Education

In December 2018, the United Nations (UN) member states, experts, civil society, and refugees developed the Global Compact on Refugees (GCR). The GCR aimed to ease the pressures on refugee host countries, enhance refugee self-reliance, expand access to third-

country solutions, and support conditions in countries of origin for return in safety and dignity (UNHCR, 2018, p. 3). This compact was adopted on top of the New York Declaration for Refugees and Migrants in 2016 and the Comprehensive Refugee Response Framework (CRRF). The GCR identified a wide range of specific needs in refugee communities that needed attention, and education was presented as one of the main needs. In light of the education needs, the Global Refugee Forum Education Co-Sponsorship Alliance developed the GFRE to operationalize the actions in the GCR and meet the commitments for refugee education.

The GFRE complemented the Refugee Education 2030: A Strategy for Refugee Inclusion (UNHCR, 2019e), which aimed to achieve the goals of the Global Compact on Refugees. Initially created in 2019, the GFRE will be reviewed every four years until 2030 to track the framework progress. The GFRE defined three outcome areas to approach refugee education: (1) inclusion in national education systems; (2) qualifications and skills for work; and (3) emergency response. Given the nature of the LED course, which consists of a higher education program with a focus on technical development, this study will specifically examine Outcome Area 2: Qualifications and Skills for Work, as the LED intersect with HE and TVET for refugees.

4.2.3 Localized Engineering as an Intersection Across Higher Education and TVET

The *localized engineering* model underscores HE and TVET by enabling learners to acquire technical, professional, and design engineering skills and to achieve higher education credits through Continuing Education Units from the Purdue at the end of the course (See in Appendix P). Hence, it contributes to the ongoing discussion of the strategies for using both educational systems to address the refugee crisis. While not aiming to provide a comprehensive guide to engineering education, this section clarifies key features of HE and TVET that intersect with *localized engineering* model and its application to engineering education in displacement. HE plays a significant role in giving young people hope and the possibility of a better life (Platzer, 2018, p. 192). As Williams (2018) pointed out, “educating adults will yield a double advantage because it will benefit the individual livelihoods of those individuals as well as the future of the children and young people who depend upon them” (p.6). Additionally, providing higher education to young populations can lead to durable solutions in crisis (Wright & Plasterer, 2010). TVET is as a specific area of training and skills development taken as part of lifelong learning (UNHCR, 2019d). Hilal (2012) pointed out that vocational training supports women and

youth empowerment, and TVET "can play an enabling role of supporting marginalized groups" (p.64) by linking vocational training to human well-being. In light of these two conceptions about HE and TVET, this article presents engineering education as a transdisciplinary field that interface science, technology, and society (Tejedor, Segalàs, & Rosas-Casals, 2018; UNESCO, 2010) towards social justice and humanitarian development.

Within our *localized* model, we learned from some facets of service learning and humanitarian engineering given the documented evidence of the value of these disciplines towards community development. This notion of community development is particularly appropriate as a baseline to foster self-reliance. Currently, a wide number of humanitarian programs emerged since 2000 as a response to calls from the international agenda to increase humanitarian development action (Smith, Tran, & Compston, 2019). Particularly in displacement, engineering expertise brought through these humanitarian programs are often needed given the number of infrastructure challenges, supply chain provision, housing, sanitation, or other pressing issues. Also relevant are the various engineered solutions often delivered from outside of the displaced community or often focused on training external actors to respond to crises far away, leading to decontextualized solutions. On the other hand, this structure reinforces existing power dynamics and contributes to a cycle of dependency. This decontextualized issue seeds our model, prompting the examination of *Localized Engineering* in Displacement.

4.2.4 Examining *Localized Engineering* within a humanitarian architecture

In our context, humanitarian architecture is a definition used to call attention to the complex cluster of humanitarian organizations in displacement (OCHA, 2007). This definition is important to highlight the importance of considering various actors to enable conditions to achieve our outcomes. While the primary focus of this dissertation is to relate this study with refugee education frameworks, there is a need to ensure that the *localized* model provides an interpretation to different actors engaged in crisis. For example, the GCR and GFRE provide a recent and comprehensive list of actors engaged in refugee education. However, these frameworks also contain some key limitations in terms of numbers of actors within each group as well as their level of implementation. Thus, it is important to recognize that findings from this study have an application limited to education. More specifically, the outcomes of our localized

model need to build solid cooperation across different humanitarian actors to achieve our goal. Given the complex nature and variety of international and national stakeholders in the humanitarian context, further studies might be necessary to expand the impact of this dissertation within this humanitarian architecture. Particularly refugee context due to diverse and unique contexts across countries. Therefore, we situate the *localized* model as a program that provides mechanisms to support learners to interface with specific stakeholders within this cluster by using the engineering skills learned in the course. Overall, we present the *localized engineering* model as a pedagogical framework that uses engineering education to help displaced learners to address local needs in different dimensions, such as food security, transportation, water, etc. At the same time, we also consider that to enhance our impact with realistic solutions, it is important to foster collaboration across a complex humanitarian cluster formed by national and international agencies, donors, non-governmental organizations, and etc.

4.2.5 Understanding the *Localized Engineering* Model

Launched in 2016, *Localized Engineering* emerged as a higher education response to provide high-quality undergraduate education for refugees that focuses on engineering design and community development. *Localized Engineering* relies upon the idea of "localization" in engineering design, rooted in contextualized solutions. LED offers a learning pathway rooted in critical thinking by fostering students' agency to create solutions for themselves and co-create course directions based on students' guidance (DeBoer, Radhakrishnan, & Freitas, under review). *Localized Engineering* incorporates aspects of active, blended, collaborative, and democratic learning. Active learning refers to engaging hands-on activities where students learn by doing (Freeman et al., 2014). Blended learning allows flexibility to suit students' needs and infrastructure limitations by integrating online resources, printed materials, and face-to-face interactions where possible (Garrison & Vaughan, 2007). Through collaborative learning, students engage in peer learning, codesign, and co-construction of knowledge (Rutherford, 2014). Finally, democratic learning, which is grounded in critical pedagogy (Freire, 1970; Wylie, 2014), works to create a space where teachers and students can exercise their roles as critical agents of change in society (Freire, 1970). The course uses engineering design as an approach to solve local problems and covers the main elements of authentic problem solving. In the

following section, we provide an overall description of the LED course implemented in the Azraq and Kakuma refugee camps.

4.2.6 LED Course Development and Implementation

The course was grounded in four learning objectives: (1) using a systematic problem solving method to identify, evaluate, and define the scope of an engineering problem; (2) applying the engineering design process to generate ideas as well as critically evaluate and develop evidence-based solutions; (3) fostering the growth of reflective individuals and empowering their social agency; and (4) discussing and practicing professional competencies. Content coverage specific to these learning objectives comprised four main topics: engineering design process (EDP), electrical and electronic systems, programming, and solar energy. EDP, as taught in the course, covered co-design, where students learned the following elements: need-finding, problem identification and scoping, concept reduction and selection, evaluation, testing, prototyping, and communication. Through this process, we used co-design to ensure the capstone projects developed in the course take end-users seriously as partners in the development process (Sanders & Stappers, 2008) as well as the local actors involved in the process, such as humanitarian agencies, local community, and donors. We also offered specific classes focused on professional development, where students learned about teamwork, communication, and feedback. The electronics module included theoretical and hands-on activities in every class session. The entire electrical engineering and electronics module relied on practical application and project-based activities where students learned how to conduct measurements and testing, identify and use engineering tools, demonstrate electronic skills in analogic and digital circuit development. The programming module provided basic programming skills so that students could create and modify the Arduino software depending on the type of sensor used in their specific circuit. Lastly, the solar energy module provided a foundational understanding of solar energy principles as an authentic design problem context. Solar energy is commonly used in the Azraq camp due to the location in the desert, and students showed interest in comprehending and using this technology in the course.

The recruitment process was a combined effort with international partners and local managers to disseminate a course callout in the camp through flyers, phone calls, SMS, and informal networks. On the flyer, we included information about the minimum criteria to enroll in

the course and expected outcomes. The course required students to be 18 years or over, understand English, expect to spend at least 4 hours of in-class activities per course week, and attend at least 75% of the classes to receive credit. Local partners recruited potential students interested in attending the course by collecting their names and locations in the camp. The final step of the selection process consisted of a pre-course workshop. This workshop included a field visit and three days of classroom sessions, where we introduced a variety of topics related to engineering design, electronics, and teamwork. The workshop culminated in an entrance exam that included word problems in both English and Arabic that asked students to describe existing engineering challenges, basic logic and math problems, and a motivation statement.

During the course implementation, the course slides, assignments, videos, and simulations, were uploaded in advance into an online platform called edX Edge, where students and local facilitators could access the course content. In both camps, the facilitators recruited in the first year were employees from local agencies with no expertise on the topic taught in the course. In subsequent years, we recruited graduates as local facilitators. Facilitators were not only responsible for providing feedback or reporting issues encountered in the classroom. Facilitators also were significant by supporting the course co-construction, managing the contextual challenges, translating the content in local language for the learners, and improving the learning opportunities of the learners. We also maintained an online presence through a social media platform called WhatsApp. Classroom sessions occurred twice a week, and local facilitators prepared the computers, electronic tools (if necessary), and course attendance. In every classroom session, online instructors were available to support facilitators and students in case of any course-related question. Throughout four months, students engaged in a blended course and, at the end of the course, students presented their capstone projects. These capstone projects consisted of student teams of four to five to create a project that addressed local challenges. The capstone projects were divided into two components: a written report, where they documented and described the processes and findings to come up with a need for a solution, and second, a physical prototype that demonstrated their technical skills learned in the course. They presented their projects to a final audience that consisted of members from the instructional team, international and local partners, and community members.

4.3 Methodology

4.3.1 Research Questions

In this paper, we address the following research questions:

- How does displacement influence the process of developing and implementing *localized engineering* in two different refugee camps?
- In the event that engineering education advances in refugee camps, as well as considering the pledges and different actors presented in the Global Framework for Refugee Education, (i) To what extent does GFRE align with existing refugee policies in Kenya and Jordan to support the development of engineering education programs? and (ii) how do refugee education stakeholders support the development of the LED course in refugee camps?

We use a comparative case study integrating two case studies in Azraq and Kakuma from a larger, multi-year qualitative research project that focused on understanding better practices to teach engineering in a connected learning environment. The comparative case study approach in this study draws on Bartlett & Vavrus (2017), who envisioned a cross-case comparison across multiple dimensions, in particular, three different axes. In this study, we use two dimensions, horizontal and vertical, to intersect our findings and lead to our recommendations. The horizontal axis is based on homologous comparison which consists of comparing and contrasting two or more cases, and evaluating how different contexts result in similar and different practices, and why (Bartlett & Vavrus, 2016, p. 52). The vertical axis is grounded in actor-network theory in this comparative case study to explore how actors interact horizontally across sites and move vertically across different local and inter/national scales (Bartlett & Vavrus, 2016, p. 77). These dimensions and their relationship with our study components are depicted in Figure 18. The vertical axis helped to trace connections among actors at different socio-political levels that directly interplay with refugee education, such as UN bodies, host government, technical and financial partners, higher education institutions, multilateral organizations, and private sector stakeholders. The horizontal axis represented the contextual challenges experienced during the course development across Azraq and Kakuma.

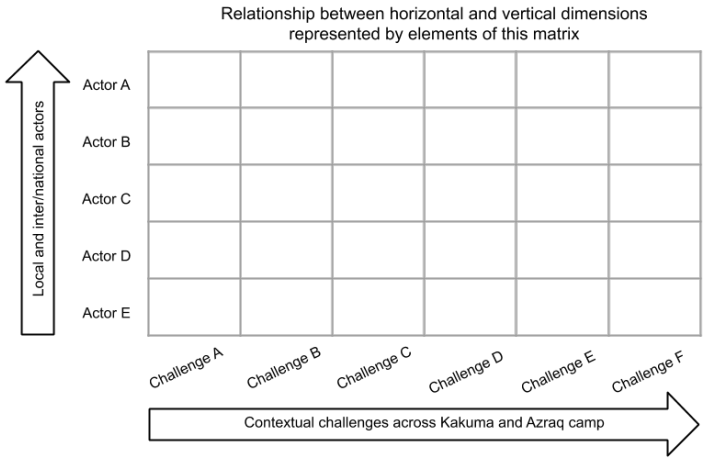

Figure 18. Components of the comparative case study based on Bartlett & Vavrus (2016)

4.3.2 Case 1: Jordanian Context

For three years (2017-2019), the research team implemented the LED course in the Azraq camp. The Azraq camp has been a temporary home for 40,000 Syrians since 2014, and it is located in an empty desert area (United Nations, 2014) in the province of Zarqa Governorate in central-eastern Jordan, 100 km east of Amman (UNHCR, 2019f). Common challenges that affect the population in the Azraq camp are the need for improvements to shelter design to protect people against the harsh desert weather conditions, to water management systems, and to avenues for freedom of movement to leave and access external aid (Al-Bakri et al., 2016; Dalal et al., 2018; Hoffmann, 2017). A total of 55 refugees (28 students in 2017; 15 students in 2018; and 12 students in 2019) participated in the course as students, and six local facilitators (2 facilitators in 2017; 4 facilitators in 2018 and 2019) supported the course development throughout three years of course implementation.

4.3.3 Case 2: Kenyan Context

Following the launch of the LED course in Azraq in 2017, we launched the course in Kakuma Camp, Kenya in 2018 and subsequently facilitated a second course in 2019. The Kakuma camp was established in 1992 in north-eastern Kenya. With a population of over 191,500 registered refugees and asylum-seekers (UNHCR, 2019b), Kakuma is one of the world's largest refugee camps. Refugees in Kakuma experience many challenges, ranging from differing

forms of insecurity (Crisp, 1999), lack of access to improved sanitation (Nyoka et al., 2017), harsh environment (Bartolomei et al., 2003), poor education quality (Mareng, 2010), and political restrictions. Added to these challenges, Horn (2010) pointed out that restrictions for employment make refugees almost totally dependent on agencies to provide for their basic needs (p. 162). A total of 38 refugees (20 students in 2018 and 18 students in 2019) participated in the course as students, and four local facilitators (2 facilitators in 2018 and 4 facilitators in 2019) supported the course development throughout three years of course implementation.

4.3.4 Sample and data collection

Our team used informed consent for original data from students and facilitators and always maintained their anonymous identity when reporting findings and information about the course. The institutional review was executed through deferral to collaborators at the University of Geneva, who had worked in the context for a longer period of time. Our sample of qualitative data is drawn across two countries where our study was situated: Jordan and Kenya. We selected these two countries as cases given the current work being developed in these settings by our research and implementation partners, and these camps are particularly illustrative of two very different sets of refugee crises, geographic, and socio-political contexts. We used data collected over three years of classes that comprised online conversations, semi-structured interviews, course artifacts, assignments, capstone projects, videos and photos, and instructor journals. For the semi-structured interviews, we strategically identified and interviewed participants who were actively engaged throughout the course. From this subset of students, we selected four participants from Azraq and five from Kakuma. We analyzed artifacts from participants that either completed or dropped the course. The interview protocols for students and facilitators contained 21 open-ended questions and generally took from 40 to 130 minutes by phone. Interviews were recorded and transcribed. The interviews were structured around participants' experience in the course, motivations, and their process to work on capstone projects. The online conversations and student artifacts were translated from Arabic and French to English when necessary by native-language speakers involved in the project.

4.3.5 Design, Analysis, and Positionality

In this work, the data analysis was concurrent with and subsequent to the data collection phase. We collected the data and analyzed patterns in the data using thematic analysis (Braun & Clarke, 2006). To ensure trustworthiness in our methodology, we addressed the criteria of credibility, transferability, dependability, confirmability, and audit trails proposed by Nowell, Norris, White, and Moules (2017). For this specific study, each case was individually analyzed; then, the comparative case study was performed. The process of coding and thematic analysis was done after approaching data with multiple perspectives, such as triangulation, peer-review across research members, and member-checking with research participants. To provide an additional degree of validity to the analysis, we performed multiple rounds of member checking with participants in the study as well as review across authors during data analysis (Denzin, 2015). The coding process started with getting familiar with every qualitative data source from 2017, then 2018, and so forth except the interviews. The interviews were used later on in the process to make meaning of initial findings and triangulation. Following this initial analysis, the primary investigator coded using an inductive approach (Thomas, 2006). The data were analyzed independently by different researchers; then, the codes and their development into themes were compared. In doing so, the researchers shared their interpretation of the data with the students and facilitators to allow clarification and refinement of the findings. The data collected were coded and analyzed using NVivo 12. The data analysis resulted in emergent themes and sub-themes illustrating course participants' experiences.

In terms of author's positionality, the first author, also the lead researcher on this study, participated actively in the course design and implementation since its genesis. The authors also have on-site experience in both camps where. As member of a multi-disciplinary team, our notions of the study grounded on our engagement in the larger project to understand our subjectivity and own perspective as researchers. For instance, we used our positional reflexivity as a lens through which we perceived the interaction between ourselves as instructors, local facilitators, and learners. Therefore, we were aware not only of boundaries in the learning space, but we also could differentiate and categorize the data collected throughout my research. Our positionality also provided opportunities to reflect upon our experiences to assess the power relations, socio-cultural behaviors, and critical epistemology when studying refugee education and conducting data analysis and reporting. The Purdue institutional review has approved

consent for all data collection activities, and ethical issues considered included confidentiality and voluntary participation.

4.3.6 Ethical Considerations

As a guiding principle, ethical complexities and contextual challenges related to research in refugee groups are recognized in this dissertation. A number of factors can influence the design and development of research in refugee camps. These factors include limited time to consolidate a relationship with the local community, problems with representativeness, gaining access to the refugee community, limited data collection, psychosocial problems, and economic incentives for the community and research participants (Ellis et al., 2007; Fegert et al., 2018; Fox et al., 2020; Head, 2009; Jacobsen & Landau, 2003; Pittaway et al., 2010). Our work takes significant note of the fact that refugees are characterized as a vulnerable population. In line with recommendations from Mackenzie and colleagues (2007) for researchers to go above and beyond the call to "do no harm," we strove to go beyond basic requirements. First, we sought to obtain "genuine informed consent." Our definition of the term is consent which is based on participants' proper understanding of their autonomy, and with it, the agency to participate in the course without necessarily agreeing to participate in the research study. Based on our IRB protocol, in order for students to participate in the study, our team issued informed consent forms, which were read and signed by all research participants after they communicated their understanding of the fact that their participation in the course was not dependent on their participation in the research study. Identifiable data were anonymized in order to maintain participants' confidentiality.

4.4 Findings

The following section presents a qualitative analysis of the data, highlighting illustrative examples of each theme. Following our research questions, the theme analysis starts by explaining the overall considerations behind each theme and displacement contexts before presenting the excerpts captured in our data analysis. We identified six themes that explained the main challenges experienced by the research team. We combined findings from each camp within the same theme given a similar impact across both camps. Overall, our broad themes were

specifically related to displacement and comprised of: emotional and psychosocial factors, limited language proficiency, inadequate infrastructure, limited digital and computer literacy, limited local teaching capacity, and restrictive policies. With respect to these themes, it is important to highlight that our field observation, positionality, and experience with education in displacement helped to delineate and confirm the impact of these themes in the course development across both camps. Throughout the course, students and facilitators used the interviews, course assignments, and online forum to talk about the challenges they faced in the course. In light of these challenges, we could assess and triangulate across multiple data sources to what extent these challenges could be connected to the nature of displacement, particularly, in Azraq and Kakuma. For example, our observations and direct conversation allowed us to understand to what extent their sense of frustration was related to the process of learning engineering or limited opportunities in the camp to apply what they learned in real life.

4.4.1 Emotional and psychosocial factors: Learning performance affected by psychosocial and emotional issues

In academic and humanitarian literature, psychosocial and emotional well-being in displacement are extensively examined, representing the interest from the international community in supporting the well-being of refugees in crisis (Fegert et al., 2018; Horn, 2010a; Jones et al., 2009). Particularly in our course, psychosocial issues were not initially explicit in the majority of participants in the early stages of the course before they were able to speak of the course experiences and share their thoughts with online instructors through online forums and interviews. For example, one facilitator in Azraq noted in the interview that ‘bringing bread on the table is the priority, so some students would drop out if they got a new job or their organizations asked them not to leave.’ It is not surprising that we found students in both camps often reporting challenging life in the camp, ‘there’s stress in the camp’; the course became an opportunity to mitigate some psychosocial issues. As one student in Kakuma noted, ‘because once we receive your call, there is courageous fillings supported to continue the life, your call contains more than you think about it.’ However, as instructors, we had to navigate between our learning objectives and psychosocial support. Some of the most significant psychosocial factors emerged from our analysis and directly connected to the learning experiences in the course, including feelings of lack of motivation, frustration, hopelessness, and concern for the family.

For example, when talking about the challenges in the camp that affect the learning process, one student in Kakuma said,

> i live with my brother who suffering from diabetes he cant do anything and aprt from that my mother and i have no any job or business to earn something for life the of this family is on my hand also my class need time so to learn in such condition sometimes i feel like i am going crazy' cuz no life without education and the duty of family is on my hand. There i could do my independent project but i stuck cuz i carry a lot in my head.

Here, the student justified his low performance in the course based on personal factors influencing his course performance. This is representative of the challenges that need to be taken into account when implementing education programs in refugee camps. Psychosocial factors, as previous research in refugee education describes (Al-Rousan et al., 2018; Brenner & Kia-Keating, 2016; Jack, Chase, & Warwick, 2019; Pastoor, 2015), also lead to cognitive, emotional, and behavioral changes. Students in both camps consistently demonstrated signs of traumas, often noting a direct connection with personal challenges that influence their motivation and persistence. As some students expressed in both camps:

> 'It requires some of sacrifice, for me when i started this course, i left everything behind so as to understand it deeper cuz when sometimes i used to interfere with my own things' (Student in Kakuma)

> 'I was strong ... but there are things that erase strength .. make you fragile .. easy breakage' (Student in Azraq)

> 'I am not satisfied with my current realistic. When I try to do a plan for help me to change my life, and it fail, I think you can imagine how I feel .!?' (Student in Azraq)

Lack of motivation seemed to be relevant throughout the course. Facilitators often reported that they 'see like a lack of interest by students' and they recognized that 'most of the students, they simply, they forget about what they have learned because they are not connected. They are not interested in learning more, or just keep learning about these things.' As referenced before, this emotional aspect played a significant role in continued course progress, and facilitators of the course also added that it is mostly connected to the reality in the camp as noted here, 'life in the camp [Azraq] is not steady, some students leave the camp some of them find new jobs so they leave the course.'

4.4.2 Limited language proficiency: Learners struggling with learning material and teaching resources due to limited English proficiency

The language barrier is a significant challenge resulting from displacement (Kosaka, 1993), with significant impact on refugee education access (Sengupta & Blessinger, 2019), since most of the education initiatives deployed in refugee camps are administrated by international organizations (UNHCR, 2020). Language barriers similarly played an important role in the LED course. To the context of our study, the language diversity was mainly connected to the distinct realities across Kakuma and Azraq, where Kakuma has English as the officially prescribed language of use in schools, but Kiswahili and various mother tongues are commonly used in education. In Azraq, learners from Syria were predominantly native Arabic speakers. Participants in Kakuma and Azraq spoke about the language barriers as an important factor that negatively influenced their learning experience or even their online interaction in the course, and this was present in both camps. As one student in Kakuma noted, 'can the videos be translated in French please? My English level is very low/down to most of expression pronounced [sic]. You will excuse me for desturbing [sic] and am very sorry please.' Similarly, students in Azraq also experienced challenges with the language of instruction: 'the videos that the students saw on the website last week were not so good or clear even the sound in Arabic not clear , so [facilitator] had to show them another video from his own laptop, we need to work on the videos especially in Arabic.'

This previous quote highlighted another relevant finding in our analysis. Language barriers seemed to have a relevant influence on the use of teaching tools in the course. For example, as our interviewees pointed out, 'the other thing is the videos in English language without translation, we think it makes the students disappointed, they just look at the video trying to understand anything, and generally they stop the video before they finish it.' Our analysis also indicated a certain degree of influence from language barriers on the classroom logistics since facilitators needed to spend additional time to translate the course material and individually support students in translation during the in-person class time. As one facilitator in Azraq pointed out, 'concerning the students, most of the students doesn't speak English, and the language is a big challenge for them, so as facilitator I need to translate the materials and their answers' and 'the situation here is all of our students this time aren't good enough at English and they need to be guide by the facilitators.' Overall, our findings indicate that the language barriers

have multiple impacts in the course, which lead to pedagogical challenges across both camps, such as challenging reality to establish an effective online communication channel between online instructors and students and ineffective use of digital tools (e.g., using an online platform, watching videos, and interacting in the online forum).

4.4.3 Inadequate infrastructure: Camps offering inadequate learning spaces for technical training and connected learning

Although both camps presented different displacement contexts, some infrastructure challenges equally affect both courses, such as poor internet, lack of electricity, unreliable transportation, and inappropriate physical spaces to provide thermal comfort and protection against harsh weather. Some of the common reports from course participants were:

> ‘Learning space allocated is small it’s really difficult to connect with other peers because we are divided in two groups and we only meet once a discussion session’ (Student in Kakuma)

> ‘Kakuma has no electricity supply, people demand on solar energy and generator, in the hub the solar installed are enough sometimes we face blackout during our classes session’ (Student in Kakuma)

> ‘This week the net was cut for one day. Also the electricity was cut off in the middle of the lesson’ (Student in Azraq)

> ‘The class finished earlier because they lost connection’ (Student in Azraq)

At the same time, each camp also presented individual challenges particular to each context. Participants in Kakuma spoke about challenges with flood, local violence, or even wild animals. For example, students in Kakuma frequently noted issues with ‘means of transport for those coming from very far’ and ‘at the moment, it is heavily raining. Students won't manage to reach to the center’, and ‘I have problems of criminals and dangerous animals like snakes, scorpions and spiders move at night which need light also solar lamps.’ In Azraq, participants spoke about challenges in terms of high temperature within the classroom and religious holidays. For example, as one facilitator in Azraq noted ‘it is very hot more than 40 Celsius and fasting for more than 16 hours. So, I do not expect to be able to complete two hours (lesson duration).’ Overall, infrastructure challenges are similar in both camps and intrinsically linked to the nature of displacement. However, to some degree, some challenges are more predominant in one

specific camp than another one, and they seemed to have a direct influence in the learning experience. For example, based on our analysis, students in Kakuma reported more cases where the local infrastructure, such as transportation, communication network, and electricity, affected the course development. On the other hand, students in Azraq also reported problems with infrastructure; however, most of these complications in Azraq emerged from restrictive policies and regulatory standpoint.

4.4.4 Limited digital and computer literacy: Learners and facilitators not prepared to use digital tools for teaching and learning

Displacement forces refugee learners to interrupt their schooling in home countries or face challenges to find opportunities to develop their skills within refugee settings (Brown, Miller, & Mitchell, 2006). Subsequently, this lack of training leads to challenges using technology tools for learning purposes effectively (Joynes & James, 2018; Leung, 2009). Learners in Kakuma and Azraq spoke about the challenges of using technology tools for learning purposes, and facilitators often reported challenges experienced by the students. As one facilitator in Azraq pointed out, ‘all the students aren't used to this kind of teaching method.’ The challenges with digital tools also expanded to the ability to use computers and software for basic functions, such as installing files or accessing the online platform. For example, facilitators often reported problems like ‘he [students] can't access his account because he tried many times his password and the account is locked can you check it please.’ or ‘I have a problem of logging in to dashboard, and my email and password are correct.’

Course participants also reported challenges while using digital learning for the first time, specially due to the unfamiliar learning environment as one student noted ‘we are used to the traditional way that the teacher is the source of all information’ and ‘at the beginning of the course, there were some difficulties at the course was new for us. Especially that it was our first time studying online. This difficulty remained for around two weeks until we began to get used to the system.’ Students also demonstrated challenges using writing tools, which strongly affected the quality of their assignments and deliverables, since, ‘they don't use it in real life’. Overall, in both camps, course participants faced challenges using the digital tools implemented in the course. These challenges seemed to be fundamentally related to the unfamiliar connected

learning environment, lack of experience with basic computer tasks and software used in the course, or even the challenge associated with using the technology tools for learning purposes.

4.4.5 Limited local teaching capacity: Insufficient local capacity to support on-site training

The overall goal of this work is to examine what factors are important to advance engineering education in displacement, and local capacity and instructors play a fundamental role in offering high-quality programs in displacement. Particularly, we call attention to the role of local facilitators in the course. As described by one of the local facilitators, 'the role of the instructors and the facilitators is to guide the students and enlighten more, and be good to the student in whatever situation they're getting through as far as the request is concerned or the studies are concerned.' While the importance of local teaching capacity is well described in the literature (Richardson et al., 2018), a number of challenges still affect the quality of teaching in refugee settings. These challenges were experienced and described in Azraq and Kakuma in a number of ways. Due to challenges to recruit trained facilitators, especially in the field of engineering, the local facilitators recruited for the LED course had limited experience in teaching and engineering. Given the lack of formal preparation of the recruited facilitators, our analysis revealed a number of teaching challenges throughout the course. In both camps, facilitators spoke about the pressure to achieve the pedagogical goals in every class and lack of preparation to support the students. As one facilitator pointed out, their role is more than logistical support because when students come to them as ask, 'Okay, you are the facilitator. Can you do this?', they felt pressure to some degree because 'they forgot that I [as facilitator] just took the course. I'm not an expert on that field for the questions that they're asking me.' Still, facilitators feel responsible for supporting students, and this required significant preparation to deal with events where their role switched from logistical support to pedagogical support. As one facilitator in Kakuma pointed out, 'we had to take a lot of time for me to go before the students, they start the class, so that they can learn and understand the topic what they are going to do. Very rewarding that when they ask question, I can be able to help them or guide them where they stuck.' Similarly, facilitators in Azraq also demonstrated commitment to being more than technical support. In fact, facilitators in Azraq took a leadership role where they supported the course by

identifying the challenges in the classroom and informed the full instructional team. For example:

> 'All facilitators discussed the problems [in the course so far], and we can summarize the problems in Azraq as we observed in these points : (1) there is no real commitment of the learners to the course time, and maybe that came as a result of the next point; (2) the students fully depend on the facilitators in the whole learning process, and they don't depend on themselves; (3) the course is designed to English native speakers, and our students aren't really good at English, and that makes more pressure on the facilitators, and takes more time to translate the content; and (4) the most important point and it's related to the facilitators, that we get the instructions too late, and that doesn't give us time to prepare.' (Facilitator in Azraq)

Overall, facilitators were mindful of considering existing conditions in the camp to support their roles as teachers (e.g., remuneration, job flexibility, and teaching certification). Our analysis also suggested that facilitators' role often switched roles according to the classrooms' and students' needs. Consequently, facilitators needed to receive adequate support to ensure they are prepared to offer both pedagogical and logistical support throughout the course.

4.4.6 Restrictive policies: Restrictive policies limit course adaptiveness to local challenges and further learning pathways

The fragile nature of refugee camps leads to extensive debates amongst international and national organizations about services and opportunities delivered in the camp. Consequently, a number of socio-political decisions are made to mediate the crisis in the camp in terms of permissions to deliver services and aid (Hilhorst & Jansen, 2010). These restrictions influence opportunities for refugees to access political and economic resources in the camp or even access opportunities to advance their learning pathways. These restrictions had direct impact on the implementation of capstone projects. As one student in Kakuma pointed out:

> 'I feel like, when we get our project to the final step and finish the final design is did not get applied to real life. They [local agencies] are not interested in implementing our projects the reason is no support because of the final support and the restrictions on us form the local authorities' (Student in Kakuma)

In light of a number of international and domestic laws created by hosting governments and humanitarian agencies that set obligations to manage the rights of refugees, it is fundamental to create conditions to advance refugee education. For example, while learning opportunities for refugees play an essential role in fostering refugee self-reliance (OECD-UNHCR, 2018), our

data analysis revealed a different reality on the ground in Azraq and Kakuma. Both camps had policies determined by the Jordanian and Kenyan government. Consequently, local opportunities and regulations were distinct across each camp. However, our analysis showed the same impact on learning pathways for both courses to some degree. For example, these two excerpts expose the direct influence from the local government during the implementation of capstone projects.

> 'I may say maybe on the issues of local government because when you want to implement something in terms of development, maybe you need to meet with the local authorities so that at least you may have the permit for you to do what you want to do' (Student in Kakuma)

> 'Sometimes they give you the support, but at the same time, there are some rules or there are some other, let me say, rules that we can't… They would just say, "It's not allowed to do this. You need to get experience to do this." And this will make a challenge for us to do. They support you, they go, "We are with you, but this is not allowed. You need experience to do this," and I worry. Sometimes, many things we need to do or prepare, we need to get something, a special permit for this, for that, and this is obstacle for us.' (Student in Azraq)

As referenced above, the participants recognized the restrictive nature of the policies to actually implement their projects. One student in Kakuma, when asked about the biggest challenges to implement their projects in the camp: 'The finding of funding is more difficult'. When answering the same question, another student in Azraq also had similar thoughts, 'mainly the lack of financial support and the restriction we have here in the camp.' Recognizing the existing barriers for follow-up on their community-focused solutions, learners and facilitators demonstrated a sense of frustration when trying to turn their ideas into a real-world product. As one participant in Kakuma noted, 'at the end of the day, we find that in the community, these guys [learners] are going back there and we see they don't do anything for the community, and the community is still suffering there.' This sense of frustration emerged very often in our analysis.

4.5 Discussion

The findings of our thematic analysis illustrate themes related to the multiple and varied challenges in displacement and show to what extent these challenges influenced the progression of the LED course. In this section, we first examine the pedagogical response for each one of the challenges presented in the findings. Subsequently, we propose a framework that illustrates connections across these contextual challenges and different actors involved with refugee education.

4.5.1 Pedagogical response to contextual challenges

We present in Table 8 a comprehensive description of the factors that influenced the course creation and our pedagogical response in both camps. The first column indicates the six biggest challenges, and the second column presents the pedagogical response from our team to these challenges. Unsurprisingly, findings were consistent across both camps, and the same contextual challenges took place across Kakuma and Azraq.

Table 8. Pedagogical response from LED to challenges in displacement in both camps

Contextual challenges	**Pedagogical response**
Psychosocial Factor	• Developed mechanisms (e.g., open communication channel and strengthen online presence) to ensure course participants can talk to instructors about non-related course subjects at any time through the message app • Promoted a gender and language inclusive learning environment (e.g., fostered dialogue to support gender diversity, age, and background to work in teams since the course kickoff) • Fostered a sense of ownership with facilitators to help them to identify signs of psychosocial and emotional issues demonstrated by students
Language of instruction	• Encouraged peer-collaboration and teamwork • Provided dual-language material related to specific technical subjects • Allowed facilitators to conduct classrooms using appropriated languages in the class independently
Local Infrastructure	• Provided funding for transportation when appropriate • Negotiated classroom logistics with local partners to allow students to use the learning resources after the class period • Created mechanisms for offline access (e.g., printed materials and dongles containing the downloadable version of the course)
Digital and Computer Literacy	• Adjusted the curriculum to include classes focused on the digital tools used in the course • Provided individual and group support to support learners to use the digital tools • Created mechanisms to foster more peer collaboration in class and supported facilitators by offering appropriate training to digital tools
Local Teaching Capacity	• Provided facilitator development program • Promoted a sense of course ownership where facilitators could participate in decisions address to the course development • Recruited alumni students to support subsequent courses as facilitators
Local Policies and Regulations	• Collaborated with local partners and implementing agencies to negotiate course time and access to the learning center outside of class hours • Engaged facilitators in the course implementation process which resulted in more sense of ownership and motivation identify alternatives to contextual challenges that affected the course development • Created mechanisms to provide funding and technical support to post-course projects • Offered continuing education credits to students that completed the course • Promoted cooperation with the local community through co-design to address the course projects to local needs

4.5.2 Relating different actors with contextual challenges in displacement

The Global Framework for Refugee Education is used in this study to name the refugee education actors. The connection between these actors and challenges experienced in our course is examined through a multiaxial representation to situate the intersection across different actors and contextual challenges in displacement. We use two dimensions representing the refugee education actors (vertical) and contextual challenges (horizontal). The vertical axis is the list of relevant actors that support the development of the *localized* model based on what is clearly underlined in the GFRE. The horizontal axis consists of the contextual challenges found during the course development and implementation in Azraq and Kakuma camp and. The role of each actor to address the contextual challenges is represented by the inner boxes that interconnect the two dimensions. The inner boxes emerged from our critical analysis of the existing recommendations from the GFRE and our research-based evidence resulted from years of research in displaced settings.

We verified that the refugee community is overlooked as a relevant actor by the GFRE. In the absence of clearly articulated positions on the part of the refugee community, the international and national institutions are unlikely to advance and develop the right policies to support future education initiatives for refugees. Hence, this article suggests one approach where the refugee community is considered a relevant actor. More specifically, we considered as part of the refugee community the refugee learners taking the course as well as the refugee community outside of the classroom. These recommendations further an understanding of how the refugee community can actively engage in educational policies, and consequently contribute to fostering their self-reliance. Indeed, there is a risk that failure to include the refugee community as a significant stakeholder in future decisions could lead to ineffective calls to action and waste of resources.

Therefore, we provided a comprehensive description of our research outcomes and practical applications to our findings presented as a table. To create this descriptive table, we used the methodological approach, as described in Figure 18, to situate the refugee education actors through a vertical dimension. Influenced by the ideas in actor-network theory (ANT), this methodological approach helps to trace actors as they form networks (Durepos & Mills, 2012) and consider these actors as part of networks where they work together to achieve a specific outcome (Sismondo, 2010). In this sense, this study underscored the roles of relevant actors (e.g.,

government agencies, donors, and local agencies) to advance engineering education in the refugee context. We read and reread the qualitative data sources and humanitarian reports to gain familiarity with the best narrative and intersection across our findings and existing recommendations from the policy arena.

We started the analysis with the GFRE, GCR, and UNHCR partner database by taking notes on the existing actors involved with refugee education and what it is expected from each actor to be involved with the refugee crisis. Next, we marked the contextual challenges from each refugee camp in our study and their connection with each actor. Our findings were then sorted into specific categories of how humanitarian reports talked about actors and their role to advance refugee education. The sorting was based on the evidence provided by the research analysis and humanitarian architecture. The rationale for categorizing such a relationship between contextual challenges and actors was to provide practical recommendations to mitigate these challenges from the engineering education standpoint as well as to call attention to the interconnection across each actor and each one of the challenges described in this study.

We also considered the specific academic literature about each one of the challenges. For example, in terms of local teaching capacity, while local teachers played a fundamental role in our *localized* model, there is a lack of research to examine the role of teachers of refugees (Richardson et al., 2018; Ring & West, 2015; Sesnan, Allemano, Ndugga, & Said, 2013). Particularly in refugee settings, Richardson, MacEwen, & Naylor (2018) pointed out four key aspects that influence the teaching efficacy: (1) teacher recruitment, certification and selection; (2) teacher preparation and development; (3) teacher remuneration and incentives; and (4) teacher retention. Therefore, we presented a model that considered each one of these four key aspects. Another example is related to language. Research in language learning revealed that learning in a second language is directly connected to social development in the classroom and knowledge acquisition process (Schieffelin & Ochs, 1986; Vickers, 2007; Wortham, 1998). Therefore, our recommendations for "Language" highlighted both the instructional materials as well as the social components influenced by peer-collaboration in class. Finally, we revisited the humanitarian reports, research-based evidence, and one more round of member-checking with refugee learners to develop a more comprehensive description of our recommendations. After making those revisions and research check in, we finalized the categories and descriptions presented in Table 9.

Table 9. Recommendations for refugee education actors

	Language	Digital and computer literacy	Local infrastructure	Teaching capacity building	Local policies and regulations	Psychosocial factors (PSS)
Host governments	Develop, recognize, and adopt certification and metrics to assess refugee's language skills	Develop, recognize, and adopt certification to assess refugees' technical qualifications and prior learning	Enable logistics on educational technologies in and out of refugee camps and basic infrastructure, such as sanitation, electricity, communication network, and transportation.	Strengthen national and international certification programs to prepare teachers to support refugee learners and integrate technology into the classroom, and ensure policies to facilitate investment on teacher training via blended learning and build the capacity of educators	Recognize engineering education curricula to facilitate mobility and transfer credits from connected learning to local higher education institutions, facilitate policies that enable the recruitment and enrollment in connected learning programs in refugee camps, and foster policies that encourage the blended and online learning in higher education and connect these programs with local educational institutions and local labor market	Revise and enable programs that recognize psychosocial support as an explicit element in the capacity training of teachers and technical curricula
Technical and financial partners	Enable partnership between language researchers with local/international education institutions and fund testing systems	Commit to funding access to certified programs and connected learning, and ensure investment on technologies and teaching preparation to enable appropriate training on how to use technologies	Increase resources to develop and enhance connected learning and technical training and fund research-informed pilot solutions addressed to inclusion and high-quality education	Ensure mechanisms to enhance or support connections between international and local teaching training, promote teaching knowledge exchange, and increase investment in teaching and training materials	Support and inform labor market opportunities for refugees, fund scholarships, higher education, scaling pilot programs across regions and connected learning initiatives, and actively invest in research, evaluation, and monitoring of connected learning programs to support scale	Prioritize programs that have psychosocial components as an evident component in the learning objectives and course implementation
I/NGOs, multilateral organizations, private sector and academic partners, and other actors	Actively engage and support initiatives to help the learners to develop second language skills and advocate for access to national/international education testing systems	Commit to ensure computing and technology courses in refugee camps, and recognize technology skills and foreign qualifications	Commit to build and maintain specific teaching spaces for connected learning and technical training	Actively seek ways to provide capacity building for local staff and teachers, and facilitate research on evidence-based models for teaching capacity	Commit to enable job flexibility for refugees attending technical and higher education programs, mobilize local network to make internships and on-the-job-training available, Facilitate research to identify gaps between refugee community, and enable cooperation among higher education institutions, committed to research to understand the learning pathway opportunities and barriers	Actively engage learners and parents in the value of technical programs, and tertiary education, and actively involve learners in program design, delivery, monitoring, and maintenance
Engineering education programs (HE/TVET)	Commit to offer dual-language teaching and training resources	Promote early training initiatives to help the learners to understand the technology tools and educational resources used in technical and connected learning programs	Decentralize education decision making across education institutions, stakeholders, and refugee community, engage in participatory actions to give a voice to local community in terms of infrastructure challenges, and commit to ensuring the refugee community develop a sense of ownership related to the resources and tools used in the course	Support integration with local education institutions to prepare and develop professionals grounded in an inclusive, culturally responsive and non-discriminatory curricula focused on refugee learners' needs to pre-service and in-service teachers	Create programs motivated on equipping refugee community with professional and life skills focused on their needs, adopt equitable access and opportunities for refugees with different backgrounds and skills, and promote inclusion focused on appropriate inclusion instead of a large number	Ensure academic and career guidance, promote a democratic and non-discriminatory curriculum, and commit to engaging for refugees and their families in the course development
Refugee community	Commit with peer-learning during the course and actively seek for language courses within the camp	Commit with course instructors to inform potential difficulties that course participants have to use the tools in the course and share their experiences with previous courses to inform good and best practices focused on their specific context	Actively seek strategies for maintaining and protecting the physical integrating of the educational resources and collaborate with instructors to manage the course inventory and technology needs	Adopt a sense of ownership with course instructors and build a collaborative environment with peers to support course implementation	Engage with local organizations to participate in educational decisions by informing expectations, difficulties, and opportunities within the camp, encourage the participation from refugees that represent different actors within the refugee community, and engage in participatory research to inform researchers about local needs	Engage with the local community to spread the relevance of technical and higher education, facilitate the engagement of instructors with local community and families, and provide input regarding what tools/platforms they want to use

As a complement to this framework, we also provide an alternative model to represent this framework through a Rubik's model representation (see Figure 19). In this model, each of the six faces was covered by four parts, each of one of four actors (as described in Table 9). he refugee community represents an internal pivot mechanism that enables moving the parts independently. In this diagram, we call attention to the importance of perceiving this entire framework as a network rather than a simple description of tasks. In other words, the association between actors might be stronger in one aspect and weaker in another, but each actor still has a minimal connection and relevance across all other actors and contextual challenges. For example, assuming that technical and financial partners (pointed out as one actor) allocated more funding to teaching capacity (blue side), this model calls attention to the potential implications of this decision to the entire network. It includes the relevant policies from host governments in terms of taxes and regulations over this funding. Subsequently, local regulations to distribute this funding across multiple local agencies. Additionally, educational institutions take advantage of this funding to reduce the cost of opportunity per student of their programs. Given the interconnection across actors and contextual challenges, this same funding might impact the existing budget available to address infrastructure challenge and all actors need to be conscious of this impact, including the refugee community. By having the refugee community as a central actor in this system, we call attention to the importance of engaging refugees on every stage as well as the importance of making decisions that fully target their needs within a policy arena.

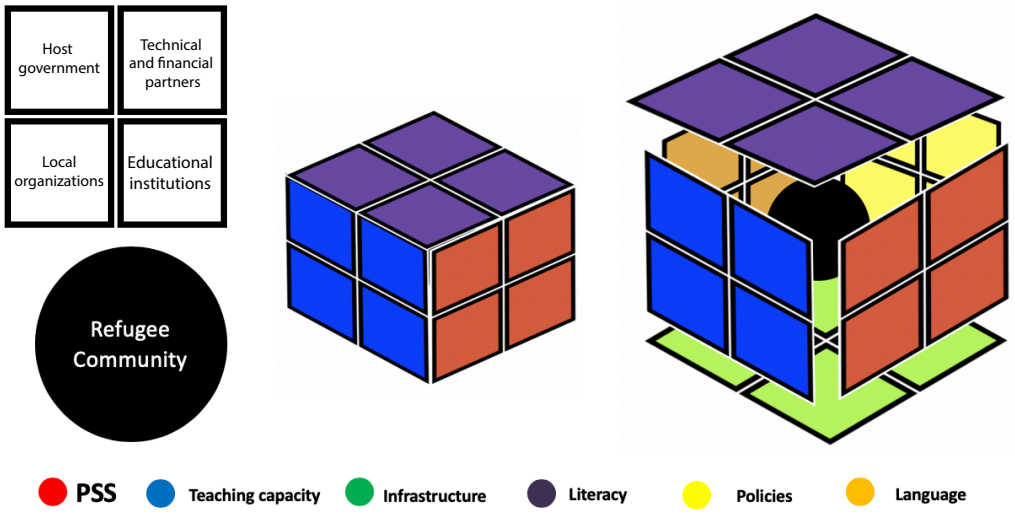

Figure 19. Framework interpretation based on Rubik's Cube mechanism

4.5.3 Alignment between Kenyan and Jordanian refugee policies with GFRE

The GFRE offers a framework to guide international and national stakeholders to meet the commitments of the Global Compact on Refugees and the Sustainable Development Goals (SDGs). In other words, the GFRE provides a basis to critically examine the pledging process for refugee education on a macro scale. However, there are important local considerations that misalign with international goals, and such misalignment exposes a critical difference between political decisions and realities on the ground in specific countries. In this study, we developed a critical analysis across the GFRE and refugee education policies from Kenya and Jordan. While our findings indicate a potential venue to use the GRFE as an effective framework to advance and scale the LED program in refugee camps, the positions of the GRFE and national refugee policies in Kenya and Jordan are different, making their interaction in the context of engineering education particularly interesting.

The context of refugee policy in Jordan is mainly represented by the Jordan Compact (Barbelet, Hagen-Zanker, & Mansour-Ille, 2018). This compact is marked both by improving access to education and legal employment for Syrian refugees, and this document has opened actions to significantly reconfigure the work and education scenario in Jordan for refugees. While the compact demonstrated a significant impact on mobilizing national and international stakeholders to approach the refugee crisis in Jordan, the Jordan Compact failed to integrate the refugee community in the global compact decisions. Consequently, the Jordan Compact still has a low impact on impacting refugees' lives positively (Barbelet et al., 2018; Gray Meral, 2019; Lenner & Turner, 2018). While the lessons from the Jordan Compact lead to a more inclusive approach from the refugee community, our analysis indicates that refugee voices have been underrepresented in relation to a recent framework on refugee education. Particularly, we verified that the GFRE failed to incorporate lessons learned from the Jordan Compact, such as actively engaging the refugee community as a relevant actor. Our experience with the *Localized Engineering* in Displacement revealed that higher education and TVET still call for attention in terms of learning pathways and restrictive policies in the Azraq refugee camp. For example, we verified that while actions have been implemented to address the education and labor market opportunities for refugees, the current scenario still poses significant barriers to advance higher education and TVET programs for refugees in Jordan in terms of recognizing course credits by

local universities and facilitating internship and job conditions for refugee learners recently graduated from these programs.

Concerning the course outcomes in Kenya, our analysis indicated that Kakuma camp still calls for resources addressed to higher education and TVET. Recent studies have found that after three years since its implementation in 2016, the GCR still faces significant barriers to achieve self-reliance in East Africa. According to recent reports, the main reasons are based on limited freedom of movement, work permissions, and payment restrictions (Crawford & O'Callaghan, 2019). Additionally, psychological and physical burdens still receive little attention in terms of its implications with self-reliance (Crawford & O'Callaghan, 2019). Launched in 2016, the Kenya Comprehensive Refugee Programme (KCRP) provided an in-depth description of the political, economic, and social scenarios in Kakuma camp. Our analysis indicated a lack of resources projected to tertiary education and TVET. In addition, the existing resource allocation to education only addresses 30% of the current needs (UNHCR, 2016b). Similar to the Jordan Compact, it does not seem the refugee community played a significant role in the decision-making process in the KCRP. In terms of our experience with the LED course, our findings revealed that Kakuma offered significant barriers to build collaboration with local universities and companies and offered a challenging environment to raise resources to develop and implement the capstone projects in the local community. While the course outcomes certainly indicate a step in the right direction, these local challenges were key to the ways in which the course did not meet the demands of the community. Particularly, the challenges experienced in Kakuma throughout the course mainly related to limited funding and political opportunities, work restrictions, and limited access to local stakeholders contradict the recommendations and calls to the action proposed by the GFRE to foster refugee self-reliance.

4.6 Conclusion

Returning to the initial purpose of this study, we expected to contribute to the ongoing discourse towards this humanitarian crisis by examining the practice of HE and TVET in displacement through engineering education. Building on a Global Framework for Refugee Framework to situate our findings within an existing policy arena, we examined the findings and outcomes across Jordanian and Kenyan contexts. Our study revealed the potential use of our *localized* model to foster refugee self-reliance. For instance, when we asked a former student of

the LED course in Kakuma to describe the LED course, the learner answered that ‘when it comes to other education provided in the camp, you learn and expect to be employed but with engineering with skills, you can apply them without being [employed]... so you can be self-employed.’ Another former student of the LED course in the Azraq refugee camp, when answered the same question, pointed out that ‘the other students, they just complain about problems and they're waiting for other people to come and solve these problems, while the engineering students, they start about thinking of how we can solve this problem by ourselves, not wait for others to solve for it us.’ In our interviews with both students, even though they lived in different refugee camps and did not know each other, both demonstrated a sense of self-reliance.

In contrast to this notion of self-reliance, the sense of frustration and lack of motivation also prevailed in our analysis. As one student in Kakuma noted, ‘sometimes I feel like we all have projects to learn but at a point when you want to study, we may do not have the support so we may do not have the funding. So you just tend to leave your projects to lie down.’ Similar frustration was also reported in the Azraq camp; as one student remarked, ‘I feel like, when we get our project to the final step and finish the final design it did not get applied to real life. They [local managers] are not interested in implementing our projects. The reason is no support because of the final support and the restrictions on us from the local authorities.’ This reality is in opposition to the self-reliance in displaced communities that the international community and humanitarian actors have been proposing and purporting to foster (UNHCR, 2018). Based on the research evidence analyzed, we argue that there is a misalignment between international goals to foster refugee self-reliance and the reality on the ground. We used a comparative case study to illuminate the contextual challenges from both camps that emerged in our analysis and demonstrate how different actors can collaborate to mitigate these challenges to advance engineering education in refugee settings. Additionally, we found that international and national refugee policies in Kenya and Jordan contradict in terms of restrictive policies for integrated education, resource allocation, and work permission. We also identified that the lack of funding and political support still offers significant barriers for higher education and technical training in refugee camps. Then, we recommended approaches that provide a baseline for different actors to address the contextual challenges that yielded this misalignment. The implications of this study

underscore the complexities surrounding HE and TVET opportunities for refugee learners, and it affirms the potential role of engineering education in fostering refugee self-reliance.

In conclusion, there is still a gap to close by giving a more significant role for refugee communities in discussion and formation of decisions. Our findings indicated that the LED seems to be an effective approach to foster self-reliance for displaced communities in refugee camps. However, significant barriers still affect the sustainability and scale process of this program across different regions and countries. In part, these barriers derived from social, economic, and environmental constraints that require a multi-actor approach to be addressed. International and national policies have pointed out these challenges and even encouraged the engagement of different actors on the refugee crisis. In addition, there is a need to review and contextualize the global framework for different countries, as demonstrated in our two cases. By showing how different actors can collaborate to mitigate the challenges found during the LED course development, we hope this comparative case study furthers debates about higher education and TVET as relevant strategies to foster self-reliance in refugee camps.

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5. CONCLUSION

5.1 Review of Purpose

The overarching research goal that motivated this dissertation was: W*hat is necessary for the adoption and utility of engineering education as a tool to meet international goals of fostering self-reliance in refugee communities?* In light of this overarching aim, three studies formed this dissertation and explored: 1) the creation and pedagogical response of the LED in a refugee camp; 2) the adoption and consolidation process of the LED framework in a different refugee camp; and 3) the relationship between multiple actors and contextual challenges to advance self-reliance through engineering education in refugee camps. The three studies of this dissertation utilized qualitative methods for data collection and analysis. The first study, as presented in Chapter 2, used an exploratory case study to describe the creation and pedagogical response of the LED course in Azraq camp. Chapter 3 also used a case study to detail the process to develop the same LED framework in a different camp by highlighting the course participants' experience. In doing so, Chapter 3 served as a rigorous approach to consolidate the LED course as an alternative pedagogy in displacement. While Chapter 4 was designed to be independent from Chapter 2 and 3, these two chapters were fundamental to develop the comparative case analysis of Chapter 4. Overall, Chapter 4 investigated the relationship between the contextual challenges in each refugee camp and multi-actors involved in refugee education. Insights combined from each of the three studies helped to illustrate what is necessary to advance engineering education in refugee camps.

5.1.1 Chapter 2: Engineering Design with Syrian Refugees: *Localized Engineering* in the Azraq Refugee Camp, Jordan

Chapter 2 investigated the course development and pedagogical response driven by three research questions: (1) What are the processes to create and implement an engineering design course in the Azraq refugee camp in Jordan?; (2) What are the contextual challenges in the Azraq camp for creating and delivering this engineering design course?; and (3) How do these challenges influence the course implementation and pedagogical response? An exploratory case study was used to investigate these research questions. I found that many students experienced

challenges to access and use the physical installations or even digital content due to poor infrastructure. I also found that students struggled with practical versus theoretical learning process. In addition, students reported lacking community support for local project implementation and limited learning pathways and formal education opportunities to advance their studies. The findings from this study suggested that restrictive reality on the ground to access education opportunities and to advance their projects and education pathways led to lack of motivation. This initial study showed evidence for the need to integrate multiple stakeholders, local partners, and the community in the course development. Hence, without an explicit plan to integrate different stakeholders and appropriate direct resources to HE and TVET, instructors and education researchers may struggle to foster and leverage engineering design and authentic learning in displacement.

5.1.2 Chapter 3: *Localized Engineering* and Self-Reliance in Kakuma Camp: Implications for Tertiary Education in Displacement

Chapter 3 investigated the process of adopting and implementing the LED course in a different refugee camp. Central to this study was examining the course participants' experiences and developing a rigorous analysis to examine the consolidation of the LED framework. I also used thematic analysis to evaluate the three research questions in this study, which consisted of: (1) What are the contextual challenges surrounding the development and pedagogical responses of the *localized engineering* course in Kakuma refugee camp?; (2) How do these challenges influence the course creation and development in this course?; and (3) How do the students and facilitators of the course report their course experience? My results suggested that barriers from displacement and cognitive capacity played a significant role as contextual challenges in Kakuma. In order to respond to these challenges, my analysis indicated five main pedagogical responses that considered: (1) facilitating the communication between students and online facilitators; (2) creating office hours to provide more support to students after class; (3) supporting post-course projects; (4) adjusting the course assignment format; and (5) enabling teacher training certification. These five responses build on current research on education in displacement and offered an alternative approach to enhance the course quality and access in similar programs.

Overall, the *localized engineering* model was well-received and accepted by course participants; however, the limited learning pathways and restrictive policies presented a challenge for many students. This is not entirely surprising, as the strong influence of challenges in refugee camps aligns with broader academic literature in refugee education (Dahya & Dryden-Peterson, 2017b; Horn, 2010a; Mareng, 2010; Wright & Plasterer, 2012). My analysis indicated that the LED course offered a transformative learning and social empowerment on the students' perceptions about engineering, which is directly connected to the efforts from instructors to share course ownership with facilitators and social presence fostered through online engagement. However, the lack of economic and political support to implement ideas developed in the course, as well as enabling conditions to access job opportunities or collaborate with community still similarly and negatively impacted the course development.

5.1.3 Chapter 4: Understanding Engineering Education in Refugee Camps: A Comparative Case Study of a *Localized Engineering* in Displacement in a Jordanian and Kenyan Refugee Camps

The novelty of Chapter 4 stems from exploring the connections of the contextual challenges in refugee camps with multiple actors. The three guiding questions motivating this study were: (1) How does displacement influence the process of developing and implementing a *localized engineering* in a Jordanian and Kenyan refugee camp? And in the event that engineering education advances in refugee camps, as well as considering the pledges and different actors presented in the Global Framework for Refugee Education, (2) to what extent does GFRE align with existing refugee policies in Kenya and Jordan to support the development of engineering education programs? and (3) How do refugee education stakeholders support the development of the LED course in refugee camps? The unique contribution of the work is in it being situated between the pedagogical landscape and policy arena, with implications for how engineering education can be advanced on the ground.

A comparative case study has identified some similarities between Azraq and Kakuma camp, but from Chapters 2 and 3, we know that the degree of challenges and pedagogical response to these challenges are distinct between the cases. By using a cross-case study, I present a framework to advance engineering education in refugee camps, particularly, the *localized engineering* model. The framework provides guidance around who to address in terms of specific

challenge dimensions and the resources and call to actions needed within each challenge. From the educational research perspective, this framework helps to understand potential challenges that could affect education programs in similar settings. From the political point of view, this framework helps to direct resources and policies effectively within the context of engineering education in refugee camps.

5.2 Connection between chapters

Through these studies, I analyzed over 90 tertiary refugee learners engaged in an introductory engineering course in two different refugee camps over a period of 3 years. In doing so, I examined their experiences along with contextual challenges in each camp throughout the course. Chapters 2 and 3 suggested similar patterns in both refugee camps in terms of contextual challenges. While findings from Chapter 2 and 3 highlighted the influence of displacement in the course creation and development, the interaction between these two studies allowed a layered understanding of contextual factors to influence the pedagogical responses. Chapter 2 suggested that Azraq has a more restrictive reality in terms of access to the camp, collaboration with the community, or implementation of learners' projects in the camp. Chapter 3 suggested that Kakuma has a strong influence from poor infrastructure (e.g., poor transportation within the camp and harsh weather) on the course development. A common element with a strong influence on the learning objectives between the two camps seems to be the lack of economic support and restrictive political regulations that offered a challenging reality to students advance their education and apply their projects and skills learned in the course. In the context of this study, economic support referred to access to funding and economic resources available to sponsor projects emerged in the course. In terms of political regulations, I referred to the permission for payment and incentives for the project development, as well as the limited freedom and logistics to ship educational tools to the camp. These two papers helped to understand that while contextual challenges are a natural consequence in fragile contexts, it is important to develop a broad analysis to evaluate this problem from a macro perspective. This is the goal of Chapter 4.

Chapter 4 examined these challenges in depth by exploring not only the nature and consequences of these challenges, but it also examined to what extent different actors can potentially collaborate to mitigate these challenges. Chapter 4 described a framework that situates the different actors and contextual challenges across camps and proposed a way by

which each actor could potentially collaborate to support the development of the LED course in similar settings. Through this framework, Chapter 4 presented a unique approach to assess the degree to which international and national actors are able to support engineering education in refugee camps. Findings may be used by educators and policymakers to understand the particular challenges related to engineering education in refugee camps that might affect higher education and TVET in similar contexts. In addition, Chapter 4 presented unique findings that highlighted the nuances and specific challenges from each camp, as generally presented in Chapter 2 and 3. To summarize the findings from each camp, I present some relevant factors that emerged in terms of demographic differentiation and its nuances, sociocultural factors, and political situation while comparing both Azraq and Kakuma refugee camp.

With respect to demographic differentiation, it was found that during the course development, it was beneficial to learn the insights and thoughts of local facilitators who were the real experts on refugee education. For example, a facilitator told me that I needed to directly engage with students and tell them how to foster teamwork or even take advantage of online tools to self-directed learning. Additionally, it was found that specific demographic dimensions, such as age, gender, language, also played an important role to enhance course experiences. For example, I noticed in both camps that gender differences affected how students interacted. In comparing the gender situation in Azraq with respect to how students developed activities during the kickoff workshop, I noticed more evidence about gender differences in Azraq than Kakuma in terms of how men and women interact or even share opinion within groups; however, the gender different also existed in Kakuma. I also noticed that language was challenging for students and facilitators in both camps. Consequently, it was difficulty for students to respond questions in the classroom or assignments in English about the impact of local problems in both camps. I noticed they felt comfortable in sharing their thoughts in their own language; however, I also noticed that they felt more comfortable sharing their thoughts with me in English as the course weeks passed, particularly in Azraq. Such a diverse context across camps interconnect with a complex sociocultural environment that needs to be highlighted across both camps.

In comparing the sociocultural situation with respect to how participants collaborated in class or advanced in the course, it was found that students in Azraq had more difficulties than Kakuma. For example, students struggled to create a gender-inclusive learning environment. In addition, the recent traumas experienced by participants in Azraq led to more psychosocial issues

reported by course participants, such as sense of urgency to apply the content learned in the course. I also noticed a more relevant perception of educational hierarchy in terms of students' role and instructors' role. I contend that this perception of education hierarchy is due, at least in part, to a monocultural environment where students are predominantly from the same country and they still experienced challenges to be part of a learning environment strongly influenced by educational methodologies implemented in a North American context. In Kakuma, the cultural situation also influenced the course experiences; however, the multicultural environment, considering that students came from different countries and cultures, seemed to have a positive impact in terms of collaboration and cooperation in the classroom. For example, in comparing with Azraq, we noticed that students had less resistance to work in teams or even in teams with different gender. On the other hand, this multicultural context may also lead to negative effect in the course, considering that different groups may have been in conflict before and they bring those conflicts along with them. Additionally, the variety of languages and dialects make the communication in class even more complex.

In comparing the political situation, most of the contextual challenges were similar across both camps. However, I noticed contextual differences across each camp in terms of their restrictive policies. For example, the Azraq camp is relatively new if compared with Kakuma. Consequently, I noticed a more challenging and restrictive environment to work with in Azraq due to security reasons. Thus, students often reported challenges to access the classroom within a specific time period, work in teams outside of the classroom, or even working collaboratively within their community due to restrictive freedom of movement within the camp. In the context of Kakuma, the restrictive policies also existed but to a different degree. Given the long period since it was established, students in Kakuma seemed to be aware of the challenges they would face by trying to implement their projects. In addition, students also demonstrated more resilience to deal with contextual challenges based on their previous experiences in different courses.

Despite the limitations in both camps, I noticed a number of opportunities to enhance the course implementation in similar settings in the future. In general, the *localized engineering* model has its potentials in displacement given the combination of various learning environment models (e.g., active, blended, collaborative, and democratic), but also its limitations, especially for contexts with restrictive policies, limited infrastructure, and learners who have little or no

experience with connected learning. The *localized* model was aligned with international goals to foster refugee self-reliance; however, because of the political and economic complexities in both camps, students may still face challenges to apply their engineering skills in local problems and advance their education. The course implementation could be even more challenging to implement without active engagement from local facilitators throughout the course implementation. Their engagement helped to mitigate challenges with gender and language barriers, for example. On the other hand, some challenges still played a significant role and require attention in future implementations, such as lacking local teaching capacity in engineering design and barriers to interface with the local community. Moreover, even if we provide an effective teaching capacity training and build stronger connections with local community, we may still face political challenges to create sustained pathways. In the next sections in this chapter, I will expand more on the specific contributions and points of attention learned in this study.

5.3 Contributions for Engineering Education Scholarship

This dissertation is impactful and contributes in three aspects: *engineering education research community, refugee education, and humanitarian engineering*. First, the novelty of the LED adds to the **engineering education research community** by examining effective teaching and learning in refugee camps. Specifically, the contributions of this dissertation relate to the application of diverse pedagogical theories (e.g., cognitive, conceptual, and constructivist theories) and learning environments (e.g., active, blended, collaborative, and democratic learning) in refugee settings. This dissertation also details the different ways in which critical pedagogy can be integrated into the engineering education curriculum and utilizes the potential for digital learning to achieve learning objectives. Additionally, work has been done exploring the adoption of multiple pedagogies and digital tools in humanitarian settings. For example, students need to get a sense of meaningful learning with a clear connection between what is taught in the course with practical implications, which implies that it is imperative that students work on real problems with enough complexity to apply what they learn in the course. Even when an authentic complex problem is in place, other strategies might need to be in place to make sure they see the relevance of the content and its application.

Secondly, in terms of **refugee education**, this dissertation offers a framework that serves as a tool to advance engineering education for tertiary refugee learners by integrating multiple actors. Particularly, the *localized engineering* model and framework presented in Chapter 4 support to development of higher education and technical training in refugee camps. The political and pedagogical components of the framework come together to expose the complex and interconnected nature of education in refugee settings. This dissertation also highlights the misalignment between international and national policies on education for refugees. My framework provides guidance and suggestion to invite actors to collaborate and provide resources to advance engineering education for tertiary learners in refugee camps. This dissertation also provides a useful model to transfer research into practice. Finally, this work initiates the conversation of engineering education as a tool to foster refugee self-reliance in refugee settings.

Thirdly, this dissertation can be considered an addition to the **humanitarian engineering** literature by creating an innovative approach to connect engineering and the refugee community. The unique contribution of this study is in it being situated between theory and practice in refugee settings. It has implications for how we can foster community development through engineering education and shift the learners to become part of the solution in humanitarian settings. Democratic learning highlights the potential to empower displaced learners and creates a model to enhance the sense of ownership and community in the classroom. Via this dissertation, I contribute with a tool for humanitarian development and participatory design through engineering education to varied contexts, such as schools in a low-resource environment, marginalized, and underserved communities. Additionally, this dissertation serves as an exemplar for research in humanitarian contexts and emphasizes the role of different stakeholders in the development of education programs and engineering projects in humanitarian settings.

5.4 Implication for Engineering Education Practitioners

My dissertation has implications for three education sectors: engineering design researchers, humanitarian engineering educators, and refugee education. Related to ***engineering design researchers***, this dissertation offers a unique opportunity to understand engineering design in fragile settings. As such, it has great potential in investigating the role of educational theories to foster effective learning in refugee camps. Moreover, because our framework consists of an

active, blended, collaborative, and democratic learning environment, it allows engineering design researchers to investigate the role of each pedagogical component during the design process, particularly the democratic environment. In an ideal engineering design environment, opportunities for capstone development through these learning environments should be abundant. However, within the refugee context, a number of challenges affect the implementation and development of capstone projects, and my dissertation offers an opportunity to understand how contextual challenges in refugee camps can affect the learning outcomes, content, assessment, and pedagogy of an introductory engineering design course in similar contexts.

Related to humanitarian development, this research offers a new perspective to ***humanitarian engineering educators*** to do participatory work in fragile settings. My dissertation informs strategies and practices to interact with different actors in displacement. First, it is important to be cognizant of how we as educators in humanitarian settings could use design language and foster social agency through engineering education. Second, the case studies and framework presented in this study have the potential to facilitate the creation and implementation of humanitarian engineering programs in fragile settings. My findings allow both a comprehensive assessment of contextual challenges in refugee camps and overall comprehension of relevant actors in the field. Although my study is focused on refugee camps, it still has implications to other educational contexts. In order to create and implement engineering education programs in refugee camps we need to better understand both how learners make sense of engineering design and how relevant actors play a role in this process.

Implications for ***refugee education*** are quite straightforward. Education is an important component of the global commitment to support refugees. As such, LED offers a pedagogical model with important implications for the refugee crisis. A number of challenges in refugee camps such as infrastructure, socio-political, and economic factors require innovative and contextual solutions. The ability to integrate local community within existing efforts to tackle the refugee crisis is important as it helps to raise their voice and create policies that address their challenges effectively. This dissertation shows the need to take a step back from international engagement to better understand the role of education in refugee settings. This level of understanding is critical so that actors involved with refugee education start from understanding

of what education currently do and need in order to address conditions to enable learners to become part of the solution for the refugee crisis.

5.5 Relating GFRE with recommendations for refugee education actors

Besides the pedagogical contribution, this dissertation was also designed to have implications for the policy arena. Hence, grounded in the GFRE, this research was fashioned to understand better the intersection of multiple actors on the advance of HE and TVET in refugee settings. This approach allowed me to create a unique framework to understand the gaps and opportunities to advance engineering education in displacement, particularly in refugee camps. My study took the first step in synthesizing the existing pledges and recommendations for HE and TVET. Based on the development of my study and qualitative analysis, I provided a comprehensive recommendation framework (see Table 9) grounded in my synthesis of GFRE and research evidence. After comparing my findings with existing recommendations, I highlight the following takeaways:

(1) *Refugee community overlooked within the policy arena*: From a political perspective, the GFRE can help stakeholders grasp the complex scenario in refugee education comprised of multiple stakeholders. However, the relevance and description still overlook refugees themselves as significant actors within the policy arena. While the GFRE states the importance of promoting meaningful consultation and participation of both refugees and host communities in decision making, the existing calls to action do not make clear this process. In addition, the refugee community itself is not even listed as part of the stakeholder group. Thus, I present a framework that proposes an alternative model where the refugee community is presented as a significant actor. Although my model focuses on engineering education in displacement, my findings can be expanded to other contexts in refugee education.

(2) *Misalignment between international recommendations and reality on the ground*: Overall, the recommendations and calls to action from GFRE inform practices that can benefit investments and efforts to advance refugee education. More broadly, the GFRE presents a comprehensive description of the socio-politic and economic scenario in displacement. However, evidence shows a different reality on the ground. While the

international discourse outlines recommendations with a broad implication, every country has a different context. More specifically, we identified significant challenges to transpose the recommendations from GFRE within the reality in Kenya and Jordan. Another factor we considered was the lack of opportunities for contextualization. Given the broad scope of the GFRE, the effort required to adapt these recommendations to different contexts is significant. Hence, my study highlights the importance to contextualize these calls to action to different degrees of crisis, countries, or even types of educational programs (e.g., engineering, language, history, etc.)

(3) *The unclear connection across multiple actors*: The role of multiple actors was determined and outlined through the GFRE. Their role is apparent when it comes to assigning tasks and responsibilities. However, the relationship and connection across these actors are still unclear. In other words, the findings from this study suggest that the association between tasks across different actors is likely the most important factor; however, this association is still unclear from the international perspective. Association between actors might be stronger in one aspect and weaker in another, but each actor still has a minimal associate across all other actors. Hence, the tasks described in Table 1 and Table 2 should be perceived as an integrated network rather than simple bullet points. My framework (see Table 9) suggests a model that makes the network across actors stronger and clear. The organizational structure described in my framework suggests a collaborative implementation where each actor directly impacts decisions to address contextual challenges.

5.6 Future Work

The studies in this dissertation show an opportunity for multiple engineering education research pathways related for refugee education and humanitarian engineering. Analysis of the course development and responsive pedagogy enable further studies in the implementation of educational theories and digital tools in similar contexts or populations, such as historically marginalized and underserved communities. Analysis of engineering design and community development embodies how students learn and practice engineering design, and the democratic component offers an alternative to investigating the use of critical pedagogy and social justice as pedagogical elements in displacement communities. These three studies can be considered the

genesis for future work. For example, Chapters 2 and 3 are set within the context of the introductory engineering course for tertiary learners in refugee camps. As such, I am able to explore the specific challenges from each camp in the development process of this engineering course. In addition, I propose news way to enhance the pedagogical practices used in these two settings that can be applied in other contexts. Chapter 4 uses findings from Chapters 2 and 3 to develop an in-depth analysis of the relevance of multiple actors on the decisions and outcomes resulted from the two initial studies. Consequently, to better understand the relationship between these actors and refugee education, a more nuanced analysis of each contextual challenge and these actors may be necessary.

Based on those recommendations, there are multiple opportunities for future research that can build on the findings of this research. One opportunity, in light of the relatively short time frame of this course, would be to conduct a similar study but, rather than looking only at how students' social agency was transformed, the new study could explore whether students' behaviors were transformed as well. Another opportunity is related to the fact that there was a lack of research evidence to support that engineering students engaged in community development may offer a significant impact to foster refugee self-reliance. This creates an opportunity to explore refugees' ability to engage in international goals by taking a role as local experts to develop solutions to their own communities.

Furthermore, the research goal is to continue developing and refining the pedagogical model based on research findings of how to implement and integrate active, blended, collaborative, and democratic learning environment. The next research steps will be to continue exploring the *localized* model in other displaced contexts. More specifically, it will be useful to develop a better understanding of engineering design, community development, and entrepreneurship pathways, as well as their connections to each other. It will also be important to develop measures for psychosocial support and community agency through engineering. Finally, the results of my comparative case study suggest several opportunities for future research in education in displacement. For example, further study can investigate the relationship between student experiences with culture, demographics, gender, and age. In addition, future studies should consider the socioeconomic and political barriers on each camp beyond the course period to get a holistic view of the alignment between the engineering curriculum and different realities.

Given the nature of this dissertation grounded in case studies, I cannot make generalizations to other contexts since this dissertation is layered upon engineering education in refugee camps in a Jordanian and Kenyan refugee camp. Future work could further the role of engineering education on psychosocial and emotional well-being for displaced populations. In addition, this study opens opportunities for qualitative study into how digital tools enable effective learning and capacity building in refugee camps would also be needed to take most of the connected learning programs in similar contexts. Overall, it is important to continue researching the learning and teaching experiences and outcomes of engineering learners in refugee camps. In doing so, we ensure that higher education and TVET can take advantage of these findings to effectively advance education initiatives in refugee camps and support self-reliance for displaced learners.

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APPENDIX A. POTENTIAL PLEDGING AREAS IN TVET

Table 10. Potential pledging areas in TVET extracted from (UNHCR, 2019c, p.26)

Host governments could pledge to:	1. Identify and mitigate barriers that prevent refugees from enrolling in TVET programs. 3. Design, adopt, and implement TVET curricula to facilitate mobility and portability of credits across institutions and borders. 4. Invest in teacher training, infrastructure, teaching materials, and training materials. Equip teachers with technical and pedagogical skills, so that they can provide engaging learning environments that are inclusive for refugees. 5. Ensure TVET curriculum is linked to national labor market demands and forecasts and that graduates have skills directly applicable to the workplace. 6. Allow all TVET graduates, including refugees, to enter the formal labor market and access financial services. 7. Ensure that degree offerings and curricula are market-oriented and respond to the need for green jobs, mobility, and work in technological fields. 8. Ensure TVET curricula are gender responsive.
Technical and financial partners could pledge to:	1. Invest in TVET teaching and learning resources and infrastructure to the benefit of the host community and refugee youth alike. 2. Provide funding and technical assistance, including funding for scholarships, for TVET institutions to include refugee students. 3. Make available information about the labor market, particularly in refugee-hosting areas. 4. Develop research to understand the employment outcomes of refugee TVET graduates and their impact on local economies. 5. Provide funding to ensure that refugees receive dedicated language support, bridging courses, and access to certified blended learning to succeed in their training and integrate successfully in the program. 6. Promote inclusive policies that allow refugee TVET graduates to access the formal labour market and obtain decent work with adequate labour protections. 7. Create mechanisms for refugee access to financial services, including digital finance.
I/NGOs, multilateral organizations, private sector, and academic partners, and other actors could pledge to:	1. Identify local economic opportunities and skill needs, including at sector-level, to guide demand-led TVET provision. 2. Promote market-linkages for TVET institutions to ensure that offered courses contribute to (local) economic development and offer relevant skillsets, including through public-private partnerships and the involvement of social partners on boards of TVET institutions. 3. Establish or mobilize local networks to make internships, mentorships, and on-the-job-training available to refugees and host community students in the appropriate field. 4. Provide capacity building for TVET administrative and teaching staff to include and integrate refugees in TVET programs. 5. Provide technical support to establish systems for the recognition of prior learning and foreign qualifications. 6. Sensitize learners and parents to the advantages of TVET as a valuable education option, in addition to (or as an alternative to) university or other tertiary education. 7. Private sector provides technical advice and confirmation that training is practice-oriented and increases employability.

Appendix A continued.

Table 10 continued

	8. Provide on-the-job training and transition to employment for refugee TVET graduates through apprenticeships or internships.
TVET institutions could pledge to:	1. Support continuing professional development of TVET teachers and trainers. 2. Provide pre-service, TVET-specific teacher education that includes training on issues of relevance to refugee learners' needs. 3. Provide academic and career guidance and psychosocial support to TVET learners as they make decisions about coursework and careers before, during, and after enrolment. 4. Ensure protection considerations are taken into account, and refugee students have access to appropriate support systems. 5. Offer entrepreneurship, critical thinking, and life skills to support well-rounded student development. 6. Facilitate the development of essential life skills and competencies through additional training and experiential learning; equip learners with effective communication skills for writing, speaking, and presenting, including digital media skills; and use foundational courses to instill respect for diversity, inclusivity and social cohesion. 7. Enable blended delivery of courses where appropriate.
Regional and intergovernmental organizations could pledge to:	1. Provide dedicated technical support so that economic and linguistic partner countries can adopt harmonized and practical cross-border and regional measures to improve access to TVET programs.

APPENDIX B. POTENTIAL PLEDGING AREAS IN HIGHER EDUCATION

Table 11. Potential pledging areas in higher education extracted from (UNHCR, 2019c, p.29)

Host governments could pledge to:	1. Identify and mitigate barriers that prevent refugees from enrolling in tertiary education institutions. 2. Ratify UNESCO's Global Convention on the Recognition of Qualifications concerning Higher Education. 3. Develop or adopt certification and assessment systems to efficiently assess refugees' prior learning and qualifications. 4. Ensure refugees have equitable access to and pay the same fees as national students in higher education institutions. 5. Utilize and share data on enrolment of refugees in higher education. 6. Recognize qualifications earned through connected education. 7. Identify and mitigate barriers to transition to employment, participation in labour markets, and access to financial services. 8. Partner with development actors to strengthen national higher education systems. 9. Prioritize partnerships that build on existing national programs for higher education and transition to employment for the benefit of both refugee and host communities.
Technical and financial partners could pledge to:	1. Ratify UNESCO's Global Convention on the Recognition of Qualifications concerning Higher Education. 2. Establish complementary pathways to expand opportunities to quality, protection-appropriate higher education opportunities in third countries. 3. Eliminate discriminatory barriers to student visas. 4. Invest in host country higher education systems, resources, and staff. 5. Advocate for inclusive right-to-work policies and encourage private sector partners to hire refugee graduates. 6. Promote and support knowledge exchange and capacity development of public higher education institutions in hosting countries and build on existing networks and initiatives. 7. Increase funding for scholarship program dedicated to refugees and vulnerable host community students in host countries.
I/NGOs, multilateral organizations, private sector, and academic partners, and other actors could pledge to:	1. Strengthen student support services to support refugee students to effectively integrate into higher education institutions and to access university services such as a guidance counselling, medical care, tutoring, community activities, and sport. 2. Promote cooperation among higher education institutions in order to expand quality academic opportunities for refugees. 3. Share and utilize data reflecting refugee higher education participation and the impact of tertiary education on refugee self-reliance, economic inclusion, and social cohesion.

Appendix B continued.

Table 11 continued

	4. Conduct research to understand the factors that influence refugee youth to complete secondary education and continue to tertiary level learning. 5. Fund refugee-inclusive higher education, language, bridging, and catch-up courses. 6. Identify and mitigate barriers that prevent refugees from enrolling in university. 7. Ensure protection considerations are taken into account, and refugee students have access to appropriate support systems. 8. Make connected education accessible to host and refugee students with the appropriate mentoring support that higher education institutions can provide, such as counseling, tutoring, career development guidance, and orientation. 9. Advocate for free or reduced access to internationally recognized language and general education testing systems. 10. Establish or mobilize local networks to make internships, mentorships, and on-the-job-training available to refugees and host community students in the appropriate field. 11. Advocate for inclusive right-to-work policies for refugees. 12. Ensure refugee populations are accounted for in national education, economic development, and development planning processes.
Higher education institutions could pledge to:	1. Expand scholarship programs for refugees and vulnerable host community students. 2. Ensure refugees and asylum seekers have equitable access to places at university and scholarships. 3. Promote and utilize a non-discriminatory curriculum for teaching about refugees. 4. Adopt welcoming campus policies and inclusive student support systems to ensure refugee students can fully integrate into academic and student life on campus. 5. Ensure teaching and support staff have adequate training to respond to the needs of refugee students. 6. Promote refugee inclusion as a component of overall internationalization objectives. 7. Host scholars at risk. 8. Promote research to inform refugee higher education programs and enhance data availability and relevance.
Regional and intergovernmental organizations could pledge to:	1. Provide technical support so that economic and linguistic partner countries can adopt harmonized and practical cross-border measures for: a. Regional quality assurance and certification mechanisms for tertiary level education. b. Regional market assessments and need-based labor mobility initiatives. 2. Implement the principles outlined in the 2017 Djibouti Declaration and other regional agreements relevant to refugee education.

APPENDIX C. RESEARCH AND MEDIA CONSENT FORM

UNIVERSITÉ DE GENÈVE
GLOBAL STUDIES INSTITUTE

INZONE

UNIVERSITÉ DE GENÈVE
FACULTÉ DE TRADUCTION ET D'INTERPRÉTATION

University of Geneva · 40, boulevard du Pont d'Arve · CH-1211 Geneva 4 · Switzerland

CONSENT TO PHOTOGRAPH/FILM FOR NON-PROFIT USE

Participant name(s):

(1) ..... (5) .....

(2) ..... (6) .....

(3) ..... (7) .....

(4) ..... (8) .....

I hereby consent to the collection and use of my personal images by photography/film.

I acknowledge these may be used for pedagogical purposes (learning materials) for higher education courses designed, developed and delivered by InZone, on the InZone website and in InZone newsletters, brochures and other forms of promotional materials.

I understand that no personal information, such as names, will be used in any of the above.
I also understand that my consent can be withdrawn at anytime by sending an email to InZone at **inzone@unige.ch**

I give this consent voluntarily.

....
Signature of person giving consent (1) Signature of person giving consent (5)

....
Signature of person giving consent (2) Signature of person giving consent (6)

....
Signature of person giving consent (3) Signature of person giving consent (7)

....
Signature of person giving consent (4) Signature of person giving consent (8)

Date .....

http://inzone.unige.ch/contact

Appendix C continued.

Purdue & Geneva University-InZone
Informed Consent Agreement

Please read this consent agreement carefully before you decide to participate in the study.

Purpose of the research study:

The purpose of the study is to improve our understanding of how refugee learners in camp settings access blended and collaborative courses in order to inform design and development of future courses adapted to learners in fragile contexts.

What InZone will do in the study:

You have been invited to sign up for or facilitate the Purdue-InZone Basic Engineering course, offered in Kakuma camp in 2019. As and if you follow the course over 12 weeks, InZone and Purdue will coordinate the support of your learning in different ways to ensure that obstacles and constraints you encounter as a refugee learner are minimized thereby ensuring that you will have the best chances to complete the course.

Time required:

Your contribution to the data collection of the study will require about 20 minutes of your time per week, about 4 - 5 hours in total over the 12 weeks of the course.

Risks:

There are no known risks involved in this study. Transport to the Learning Hubs carries risks. These are beyond the control of InZone and Purdue University and neither InZone nor Purdue can assume responsibility for them.

Benefits:

There are no direct benefits to you for participating in this study other than your potentially improving your understanding of Basic Engineering, and your ability to learn more efficiently and effectively online. The study may help us understand the usefulness of open educational resources (OERs), of collaborative learning across different locations in fragile contexts.

Data linked with identifying information:

The information that you give in the study will be handled confidentially. Your information will be assigned a code number. The list connecting your name to this code will be kept in a locked file. When the study is completed and the data have been analyzed, this list will be destroyed. Your name will not be used in any report.

Admin Use Only	
Protocol Name	InZone – Azraq HE space
Approved Ethics Committee	from: to:

Appendix C continued.

Anonymous data:

The information that you give in the study will be handled confidentially. Your data will be anonymous which means that your name will not be linked to the data, only to the location in which you reside.

Voluntary participation: Your participation in the study is completely voluntary.

Right to withdraw from the study: You have the right to withdraw from the study at any time. Withdrawing from the study does not mean that you also need to withdraw from the course. You may continue learning in the course, but not participate in the research.

How to withdraw from the study: Should you wish to withdraw from the study please inform the principal investigator (Barbara Moser---Mercer) immediately via e---mail (Barbara.moser@unige.ch). All data collected prior to your decision to withdraw will be destroyed.

Payment: You will receive no payment for participating in the study.

If you have questions about the study, contact:

Barbara Moser-Mercer
Barbara.moser@unige.ch

Agreement:

I agree to participate in the research study described above.

Signature: _____
Date: ____

You will receive a scanned copy of this form for your records.

APPENDIX D. CAPSTONE PROJECT RUBRICS

Your Name: _____E-mail: _____

Rubric Reference Guide

Please follow the instructions on this page to use this rubric for students' design review presentation. Our goal is to provide a fair assessment and feedback of students' progress towards the intended learning goals. This document was designed to facilitate your observation and judgment as an external observer. We greatly appreciate your expertise and involvement in this process.

Step 1

Before starting to complete this document, please read and be familiar with **Evaluation Rubric** on the next page to understand the evaluation rubric.

Step 2

Listen to the presentation of each team and provide a score between 0-3 (cf. page 2-3) for each evaluation objective based on the criteria listed. After evaluating each team, provide your overall comments/suggestions to help the students improve their design (cf. page 4). This table could serve as space to record any additional suggestions (other than your verbal feedback) or a note-taking space as you view the presentations. For example, if you see a team clearly list out "Three or more pieces of evidence…in support of the problem statement.", you could circle this item in the "Excellent" column of the **problem scoping** rubric row.

Step 3

After all the presentations are over, please fill out the **General Reflections** sheet (cf. page 5) describing your reflections from the students' work. These words should reflect your overall impression regarding the overall performance of all teams, especially the moments that stand out to you.

Course content	Evaluation objectives	3-Excellent	2-Good	1-Satisfactory	0-Unsatisfactory
In the course so far, the students did the following activities related to **PROBLEM SCOPING**. Identified multiple problems in the community/learning hub Selected and justified the choice of a local problem faced in their community Articulated the problem statement	State the chosen problem and justify its selection with relevant evidence	The chosen problem is relevant to the community/learning hub needs. Team clearly articulated the problem. Three (3) or more pieces of evidence were given in support of the problem statement.	The chosen problem is somewhat relevant to the community/learning hub needs. Team didn't succeed in stating the problem in a clear way but was able to convey the message. Two (2) clearly formulated pieces of evidence were given in support of the problem statement.	The chosen problem is irrelevant to the community/learning hub needs. The problem statement was ambiguous/unclear/short/incomplete. One (1) piece of evidence was given in support of the problem statement.	No problem statement was given.
In the course so far, the student did the following activities related to **DESIGNING THE SOLUTION**: Developed a final solution Articulated a statement of solution	Justify the choice of the design solution for the identified problem	The final solution is clearly articulated – (has a clear description of how it will solve the identified problem)	The final solution is somewhat clear – (has a weak description of how it will solve the identified problem.)	The final solution is unclear - has an unsatisfactory description of how it will solve the problem.	No ideas were generated

Appendix D continued.

Identified and justified a selection of the parts that will be used to build that final projects	Present the characteristics of each part of a physical or virtual prototype	There is a clear description of parts of the prototype and their characteristics. (Presents sufficient evidence of the functionality of at least 10 parts of the final solution and a description of how each meet design requirements.)	Parts are partially identified, and description of the parts' characteristics lacks clarity. (Presents limited evidence of the functionality of between 5 to 10 parts of the final solution and a description of how each meet design requirements.)	Parts are scarcely identified and characteristics of the parts are poorly described. (Fails to present evidence of how the parts of the final solution meet the design requirements.)	No justifications were provided for the functionality of parts of the final solution
In the course so far, the student did the following activities to **TEST THE DESIGN SOLUTION.** Constructed prototypes (physical or visual) applying basic engineering tools	Construct a physical or visual prototype	Constructed a full physical/visual prototype.	Constructed a physical/visual prototype with limitations.	Constructed an incomplete physical/visual prototype.	No prototype (physical or visual) constructed.
In the course so far, the students have done the following activities to gain **PROFESSIONAL COMPETENCE**. Learned principles of effective communication Learn about various team roles and responsibility Developed a code of cooperation Practiced teamwork	Communicate the design solution within the allotted time and explain the contributions of team members	Delivered a clear, understandable, and coherent presentation. Respected the time allotted for presentation. Demonstrated knowledge of team members' contributions.	Delivered a somewhat unclear presentation but succeeded in conveying the core message. Went 5 minutes beyond the allotted time. Demonstrated poor knowledge of team members' contributions.	Delivered an unclear, incoherent presentation. Went 10 minutes beyond the allotted time. Demonstrated no knowledge of team members' contributions.	No presentation was delivered.

Overall comments	**Team 1**	**Team 2**	**Team 3**	**Team 4**
Notes/suggestions for improvement				

Appendix D continued.

Reference B. Reflections

After the presentations, please describe here your impressions reflecting on the performance of all teams. If you need additional space for answering one of the questions, please use additional blank space on the back of this page.

NOTE: Feel free to include any additional behaviors observed for specific teams or individual students.

1) What moments stood out to you during the presentation of each team? Could you describe one moment that caught your attention from one or more teams while they described their project?

2) Did you notice moments of leadership, collaboration, or any other professional skills learners demonstrated during their presentations? Please describe these moments.

3) Do you feel they were able to answer all questions posed to them?

APPENDIX E. LIST OF EQUIPMENT IN THE CLASSROOM

Equipment	Quant
Sensors	
Temperature sensor LM35	5
Photoresistor	5
Water Sensor Rainwater Module Detection	5
Infrared Sensor	5
Water level Sensor	3
2 Channel DC 5V Relay Module	5
Servo Motor kit	5
Smart Home Sensor Modules	1
Water flow sensor	1
Optical Dust Sensor	1
Metal detector sensor	1
Ultrasonic sensor	2
Electronic components - general purposes	
Resistor Kit	2
330 Ohm resistors - pack 200	1
Capacitor Kit	1
LCD display	2
Prototype PCB 12x18	10
Male Pin Header Connector	1
Screw Terminal	15
Potentiometer 10K	7
LED 5mm	30
Push button	10
ON/OFF button	10
Transistor Kit	1
Data logger Arduino	1
SD card	1
Converter SD to USB	1
Solar Kit	
ALLPOWERS 2.5W 5V/500mAh	2
Regulator DC Buck Converter	2

Appendix E continued.

Development Kit	
Arduino Uno R3	7
Power Adapter for Arduino 2pc	7
USB Mini-B Cable	7
Lab equipment's	
Stanley Mixed Tool Set	1
4-Piece Pliers Set	1
Flush cutter	1
Multi-Tool Wire Stripper	1
Hot Glue Gun	1
Glue Gun stick	1
Electrical Tape Value	2
Stanley 68-012 All-in-One Screwdriver	2
Wire female/male	100
Breadboard Jumper Wires (Multiples)	4
Breadboard	7
Hardware and Craft Cabinet	1
Solder Wire	10
Soldering Iron Station	1
Desoldering pump	1
Solder sucker	1
Multimeter	2
Fuse Kit	1
Test Leads	1
Power Supply 30V/5A	1
Helping third hand	1
Caliper	1
20M Extension Wire Cord	2
Alligators Clips	1
Miscellaneous	
Flash Drive 8GB	1
Book Make: electronics	1
Book Programming Arduino	1
Safety Equipment	
Protective Eyewear	7

APPENDIX F. ENTRANCE EXAM AND DETAILED RUBRIC

Introduction to Engineering Course Entrance Exam

Answer in English, French, or Arabic, whichever you feel is more comfortable for you.
Question 1.
A] What is your definition of an engineer?

B] What skills and knowledge do you think are required to be an engineer?

Question 2.
A] Why would you like to be part of this project?

B] Give us an example of how you will benefit from this course.

Question 3. Find the next number in the series:
If
2 ◊ 1 = 23
2 ◊ 3 = 65
4 ◊ 2 = 86
5 ◊ 4 = 209
Then
6 ◊ 3 = ___

Question 4. What is the result of this equation?
$9 - 4 \times 2^2 + (36 / 3) - 3 =$ ____

Question 5. Observe the picture below and answer the following questions.

A] Write one problem that you can identify from the picture.

B] Propose a solution to the problem. Describe and explain your solution.

C] Explain the step-by-step process you used to solve the problem.

Available times during the week

What time would be best for you attending the course? Please mark one or more boxes.

Note: Each cell has a window of 2 hours.

Sunday	Monday	Tuesday	Wednesday	Thursday
9am – 11am	9am – 11am	9am – 11am	9am – 11am	9am – 11am
10am – 12pm	10am – 12pm	10am – 12pm	10am – 12pm	10am – 12pm
11am – 1pm	11am – 1pm	11am – 1pm	11am – 1pm	11am – 1pm
12pm – 2pm	12pm – 2pm	12pm – 2pm	12pm – 2pm	12pm – 2pm
1pm – 3pm	1pm – 3pm	1pm – 3pm	1pm – 3pm	1pm – 3pm
2pm – 4pm	2pm – 4pm	2pm – 4pm	2pm – 4pm	2pm – 4pm
3pm – 5pm	3pm – 5pm	3pm – 5pm	3pm – 5pm	3pm – 5pm

Detailed Rubric

Questions	**0**	**1**	**2**	**3**
1A: Definition of an engineer				
Professional language Note: this merely assesses the mention of these terms	No response	Mentions problem-solving	Mentions problem-solving or describes the engineering design process or the tools used	Mentions problem-solving, describes the engineering design process, and the use of tools like math, science or technical tools
Elaborate arguments Note: this assesses the logical connections between the terms mentioned above	No response	Connection with problem solving or provided response is clear	Connection with problem-solving, use of technical tools and engineering design process is clear	Connection with problem-solving, tools, and engineering design process is clear and justified
1B: Skills and knowledge required to be an engineer				
Professional language	No response	Mentions scientific knowledge	Mentions 2 technical skills	Mentions 3 or more skills (technical, scientific, mathematical, etc.)
Elaborate and detailed explanation	No response	Connection with scientific knowledge or response is clear and/or justified	Connection with mentioned skills is clear and/or well justified	Connection with skills is clear and/or well justified
2A: Reasons for being a part of the course (consult sheet titled “Motivation”)				
Professional language	No response	Mentions 1 of 9 options listed	Mentions 2 of the 9 options listed	Mentions 3 or more of the 9 listed options

Appendix F continued.

Elaborate and detailed explanation	No response	Connection with mentioned option is clear	Connection with mentioned options are clear	Connections with mentioned explanations are clear
2B: Examples of benefits from the course (consult sheet titled "Motivation")				
Professional language	No response	Mentions 1 of 9 options listed	Mentions 2 of the 9 options listed	Mentions 3 or more of the 9 listed options
Elaborate and detailed explanation	No response	Connection with mentioned option is clear	Connection with mentioned options are clear	Connections with mentioned explanations are clear
3: Math operation question				
Use accurate scientific math, technical logic	No response			Correct response
Showing work	No response	Shows working		
4: BODMAS				
Use accurate scientific, math, technical logic	No response	Performs multiplication/division first	Performs addition & subtraction next	Arrives at correct response
Showing work	No response	Shows working		
5: Engineering problem identification, stepwise solution				
Professional language The following mentions are for questions 5A and 5B	No response	Mentions trash, rubbish, dustbin, dirt or clean-up	Mentions fire hazard, fire extinguishing, and health hazard	Mentions pollution, land pollution, environmental pollution, recycling, proper disposal
Supports all claims made with evidence	No response	Connection to the above-named terms are justified or clear	Connection to the above-named terms are justified or clear	Connection to the above-named terms are justified or clear
Client, user, and other stakeholders	No response	Mentions 1 stakeholder	Mentions 2 stakeholders	Mentions more than 2 stakeholders
Justifies solution design based on criteria constraints	No response	Solution steps are logical and/connect to stakeholder	Solution steps are logical & connect to stakeholders in the context	Solution steps are logical, connect to stakeholders in the context and identify engineer's role

APPENDIX G. SEMI-STRUCTURED INTERVIEW QUESTIONS

STUDENT INTERVIEW PROTOCOL

Name: **Date:**

Interviewer introduction: Before we can begin with the actual questions, do I have your consent to record this conversation? I also have an information sheet that I'd like to go over. The purpose of the research is to enhance engineering education in emergencies. And the interview will last about 60 minutes; no longer than an hour. Because it's voluntary if there's a question you don't want to answer you can let me know. And, if you want to stop at any time just let me know. It's completely confidential and this is probably the most important part. Your name will never be associated with any of the recordings, the transcription, nor any of the results. In fact, even the recordings will get destroyed after they're transcribed. Do you have any questions before we start?

Part A. (Course experience)

1. **Walk me through your experience in the course.**

a. How would you define the main challenges experienced in the course as student? (Could you cite examples?)
b. Do you think this course addressed or mitigate those challenges? Why?
c. Did the way of structuring and implementing the course fit the reality in the camp? Why?
d. How would you describe the course to an interested future participant?
e. During the course was there ever a time when you experienced a difficulty understanding engineering concepts? If yes, when?
f. Did you learn engineering skills from the course? If so, how did you apply those in your daily life?
g. What do you think of the way which we structured the course in terms of access to the course and classes?
h. What do you think of the way which we structured the course in terms of your learning experience?
i. What do you think of the way which we structured the course in terms of how we taught it?

Part B. (Engineering course perceptions)

1. **Walk me through your perceptions of the engineering course:**

a. To what extent this engineering course differs from other education opportunities in the camp?
b. How would you describe the role of technology in this course?
    a. Follow-up question: Could you cite examples of when these technologies were effective or not to delivery and evaluate students?
c. How would you describe the role of the facilitators, local management, and online instructors in the course?
    a. Follow-up question: In any moment throughout the course, did you feel their decisions had a positive or negative impact in your learning experience? Why? (examples)

Part C. (Engineering design and society)

1. Walk me through your perceptions of engineering design and society.

a. What do you consider as a local community?
b. As engineering student, what is your role in the local community and why?
    a. Follow up question: *Speaking as a non-engineering student, what would be your role in the local community and why?*
c. How do you see engineering design helping you to solve problems in the local community?
d. How do you see your role as student in the process of using engineering design to solve local problems?
e. How do you see the role of instructors and facilitators to support you to develop your engineering design project?
f. Do you feel you have support from local managers to develop your ideas in the camp? Why?
g. What are the main barriers to transform your concept design in a real solution in the camp? (examples)
h. What do you think of the way which we connected engineering design to local problems? (example: when we mentioned that you could use engineering design to create solutions to the learning center.)

Open-end question: Thanks for your time and excellent answers. We really appreciate your participation in the course and collaboration so far. I would like to ask a final question. "How would you describe this course for a future student?"

FACILITATOR INTERVIEW PROTOCOL

Name: **Date:**

Interviewer introduction: Before we can begin with the actual questions, do I have your consent to record this conversation? I also have an information sheet that I'd like to go over. The purpose of the research is to enhance engineering education in emergencies. And the interview will last about 60 minutes; no longer than an hour. Because it's voluntary if there's a question you don't want to answer you can let me know. And, if you want to stop at any time just let me know. It's completely confidential and this is probably the most important part. Your name will never be associated with any of the recordings, the transcription, nor any of the results. In fact, even the recordings will get destroyed after they're transcribed. Do you have any questions before we start?

Part A. (Course experience)

2. Walk me through your experience in the course.

j. How would you define the main challenges experienced in the course as facilitator? (examples?)
k. Did the way of presenting the course fit the reality in the camp? (yes / no / partially / unsure). Why?
l. How would you describe the course to an interested future participant?
m. Do you think the course teach engineering skills? If so, how can students apply those in their daily life?

Appendix G continued.

n. What do you think of the way which we structured the course in terms of access to the course and classes?
o. What do you think of the way which we structured the course in terms of students learning experience?
p. What do you think of the way which we structured the course in terms of how we taught it?

Part B. (Engineering course perceptions)

2. Walk me through your perceptions of the engineering course:

d. To what extent this engineering course differs from other education opportunities in the camp?
e. How would you describe the role of technology in this course?
    a. Follow-up question: Could you cite examples of when these technologies were effective or not to delivery and evaluate students*?*
f. How would you describe the role of the online instructors and local management in the course?
    a. Follow-up question: In any moment throughout the course, did you feel their decisions had a positive or negative impact in your teaching experience? Why? (examples)

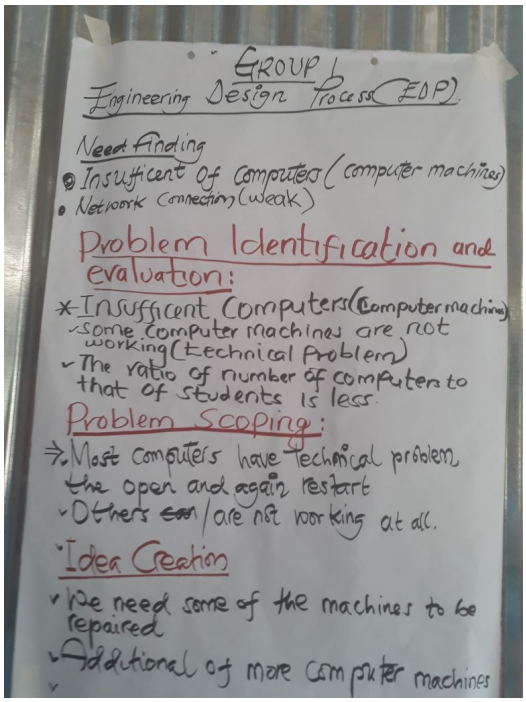
Part C. (Engineering design)

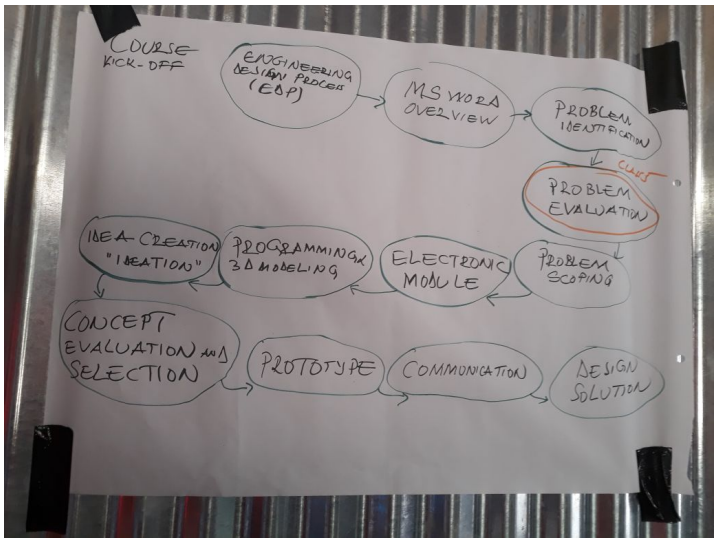
2. Walk me through your perceptions of engineering design and society.

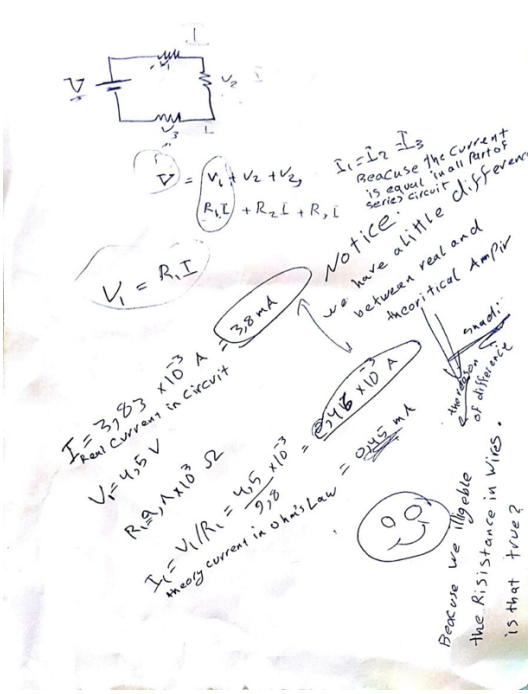
i. What do you consider as a local community?
j. What is the role of the engineering students in the local community and why?
    a. Follow up question: *Speaking as a non-engineering student, what would be your role in the local community and why?*
k. How do you see engineering design helping students to solve problems in the camp?
l. How do you see your role as facilitator in the process of students using engineering design to solve local problems?
m. How do you see the role of local community and facilitators to support students to develop their engineering design project?
n. Do you feel students have support from local managers to develop their ideas in the camp? Why?
o. What are the main barriers to transform students' concept design in a real solution in the camp? (examples)
p. What do you think of the way which we connected engineering design to local problems? (example: when we mentioned that students could use engineering design to create solutions to the learning center.)

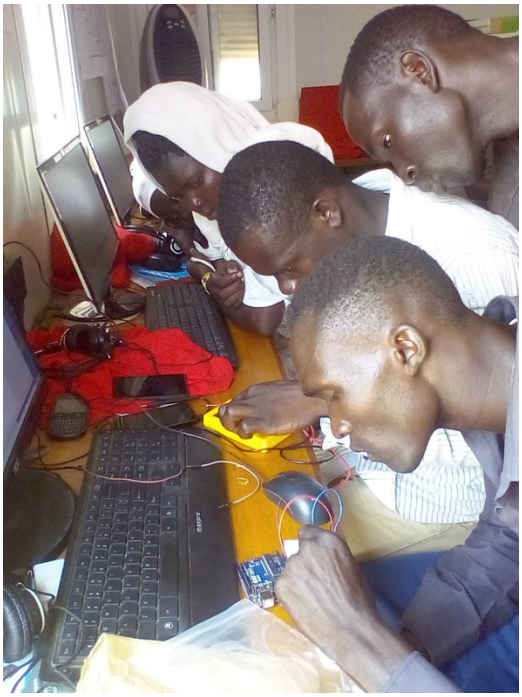
Open-end question: Thanks for your time and excellent answers. We really appreciate your participation in the course and collaboration so far. I would like to ask a final question. "How would you describe this course for a future student?"

APPENDIX H. EXAMPLE OF COURSE ASSIGNMENT

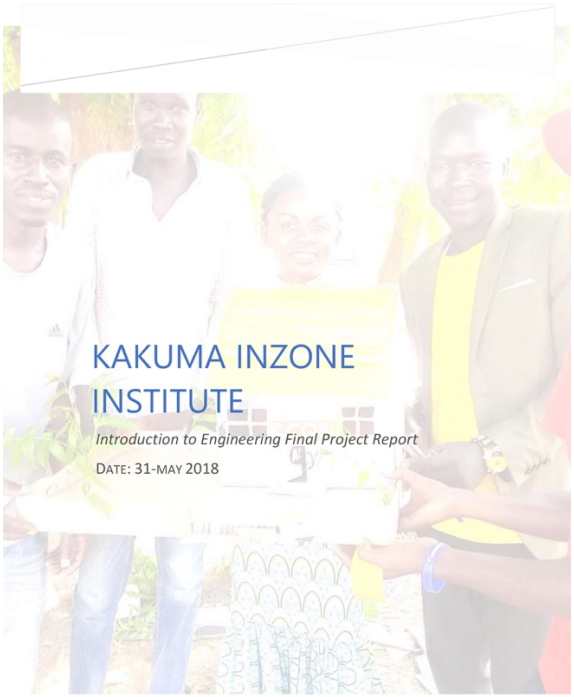


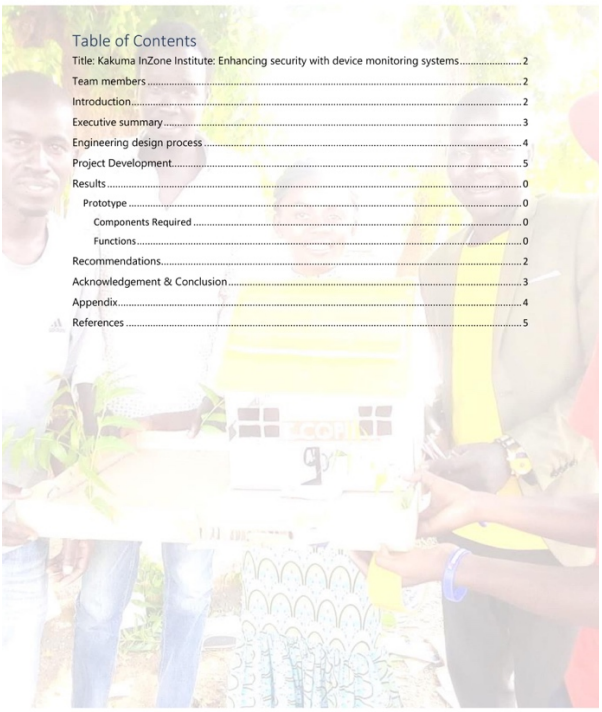






APPENDIX I. EXAMPLE OF CAPSTONE PROJECT





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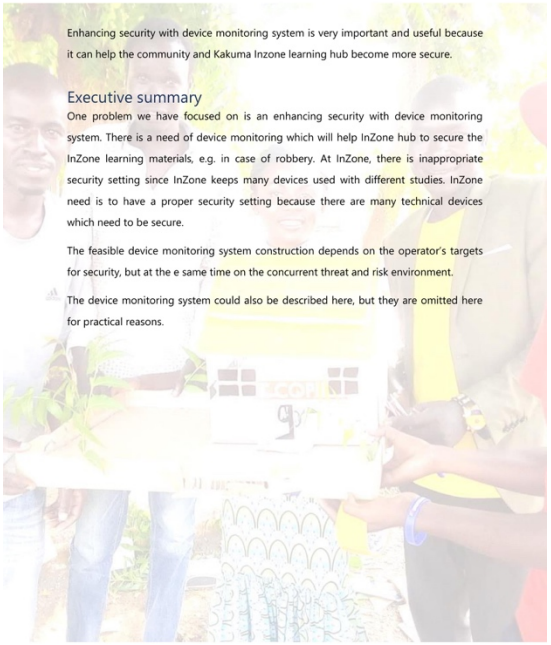
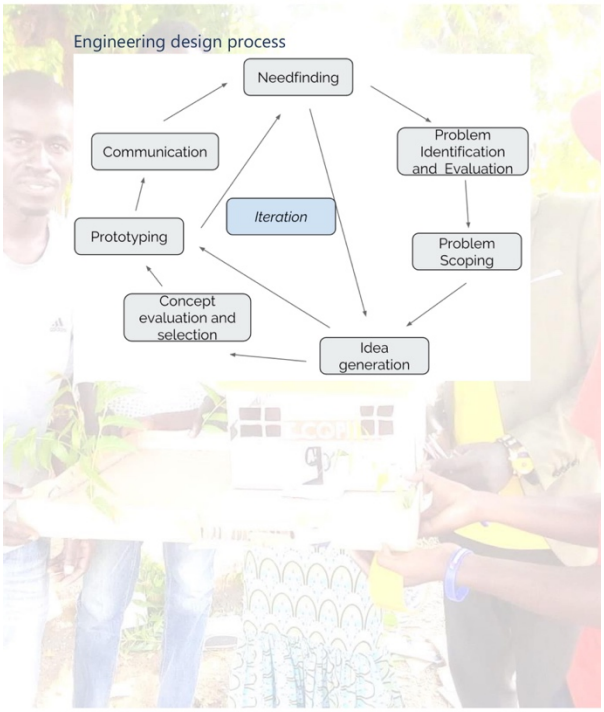


Appendix I continued.



INITIAL IDEA GENERATION:

IDEAS	PRO	CON	CATEGORY
1.The room should be build large.	The room to be have fresh air as the room ceiling is high.	It takes time and a lot of materials.	CIVIL
2.The room should be built with windows.	Good for ventilation.	Materials are costly.	
3.The room should be tall.	Help tell people to move freely.	It takes time to build tall room and expensive.	
4.We must have like 2 to 3 ventilators (AC).	Make room to be cold and machine not to shut down because of hotness.	Very expensive.	
5.Build room with reflecting material which can reflex light.	For room to have fresh air.	Material for building are expensive.	
6.The sitting arrangement in the room should be separated.	Help learner to do his/ her own work separately.	Very expensive.	ACCESS:
7.Make round table for group discussion for part pant to face each other at least to be active in group discussion.	Make people to have space for discussion without interrupting with computers/learning material.	No space for constructing round table.	
8.Create movement space for trainer/facilitator.	Make the work of facilitator comfortable with his duties.	It need large/big room to create space.	
9.Create \build ramp for person with disabilities.	It helps people with disabilities to move with wheel-chair freely.	It takes time to construct and it is expensive.	
10.Separating computer for each leaner to access or learn without other learner person to copy.	To make a person to do his/ her own work in time of exams.	Separating materials are expensive and it need a large room.	
11.Every leaner should have computer that has its own system unit.	It helps every computer not to shut-down at the same time as each computer have its own unit.	Very expensive.	
18.Planting more trees around the learning center	Fresh air.	Take time to grow.	
19.Room must have two doors entrances and exit	Help in movement of people in and out.	Interrupt learning.	
20.plug of earphone for everyone to listen when display videos	Easy to understand the video display.	Can damage the ears.	
12.Place/or put 2/3 cupboard for material to be kept in.	Keep material for safety.	No space for 2/3 cupboard because room occupied with learning material.	
13.Cemented the floor to prevent the dust	Help to smooth the floor.	It takes time to dry-up when it's mob or clean using water.	DUST: Maintenance
14.We need dust cover to protect the machine	Protect learning machine not to damage.	Very expensive.	
15.Place a mouse in soft ground or place not rust	It helps mouse not to rust and move without producing sound.	Expensive to make it.	
16.Generator should be bought in case of weather condition	Help restore power when batteries goes off due to weather. e.g. raining	Very expensive.	POWER
17.UPS should be bought in case power interruption it with not interfere learning	In case it is raining or there is bad weather condition.	It needs good maintenance.	

Project Development

PROBLEM EVALUATION:

Problem	Can we solve it using technology tools? e.g., electronics?	Who are the different stakeholders concerned (direct and indirect users)?	How important is this problem to the stakeholders?	Why is this an important problem for these stakeholders?
Room is small it is too hot	2 – medium relevance	Students Community members Refugees staff	2	It will help students to provide a space of accessibility for the courses at the same time. When a visitor comes, it will assist the learners and facilitator to sit/ learner in comfortable place.
Need more A/C or air condition	3 – very technologically relevant	Staffs Students	4	It will be important for the students because it will help them to learn well
Learning space distance from home	2- medium relevance	Staffs Students	2	When more hubs are provided, will get more students getting interested to learn. Due to financial traps it's affect those who are far from the learning center.

Appendix I continued.

Results

Prototype

For this project we have the materials which will be helping us to develop this project.

Components Required

- ARDUINO UNO
- PIR SENSOR
- CAMERA MODULE
- ZIGBEE MODULE
- CONNECTING WIRES.

Functions

- ARDUINO UNO: is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers.
- PIR SENSOR or passive infrared sensor (PIR sensor): is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors.
- CAMERA MODULE: is an image sensor integrated with a lens, control electronics, and an interface like CSI, Ethernet or plain raw low-voltage differential signaling.
- ZIGBEE MODULE: is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection
- CONNECTING WIRES: allows an electrical current to travail from one point on a circuit to another because electricity needs a medium through which it can move.

We are working on "Wireless surveillance system using ZigBee".

IDEA EVALUATION

IDEA	DURABILITY(3)	FEASIBILITY(5)	TECHNICAL APPLICATION(5)	SUSTAINABILITY (3)	TOTAL
1. The room should be build large.	2 adequately durable, because it will be used for longtime and help many generation.	3 highly feasible, because it had time limit.	3 highly technically relevant idea, because it need people who here knowledge about it.	3 high sustainability, because they cement, brick, and leveling the floor for it to permanent and stay for long	45
2. The room should be built with windows.	2 adequately durable, because windows will be constructed with material that can last for many years (glass windows).	3 highly feasible, because it needs people who are well train.	2 highly technically relevant idea, because well trained personal who can fix flexible windows.	2 highly sustainability, because use glass and metal windows to be durable.	37
3. The room should be tall.	2 adequately durable, because build with metal poles to make the roof tall for it be durable for longtime	3 highly feasible, because it needs material which can last for longtime.	3 highly technically relevant idea, because use metal-poles and material which will be constructed /build by well-trained engineer	2 high sustainability, because fix or construct with metal-poles to make room tall.	42

FINAL IDEATION

In order to face the described problem related to security, we have come up with a device monitoring idea:

- To build a durable learning hub with gate.
- To look for security man.
- To create a device monitoring system which will control all movement in the community and to the Inzone learning hub.

But we want to add external PIR motion sensor and wireless ZigBee module with Arduino.

The images are stored in SD card. but my goal is when the PIR detects any motion the image should be stored in memory card (Done in attached code) and then that image should be transferred through ZigBee (ZigBee TX is connected with Rx Pin0 and ZigBee Rx is connected with TX Pin1). PIR sensor output is connected with Pin7 of Arduino. And the prototype is:

Pictures:

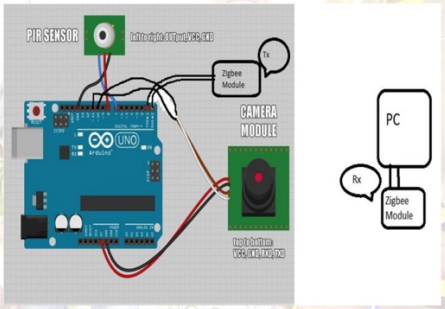


Figure 1: A schematic view of what?

This is a monitoring device which has a function of secure something, or somewhere. In short cut it help to make security.

Figure 3: Actual Prototypes

For this we want to show you how this thing will be working in InZone. This prototype is an example of InZone and that device monitoring. This device monitoring will be controlling all movement and situation done inside InZone compound and outside at 5m to InZone compound.

Recommendations

- In our group we have missed some materials to finish our work better with a video report.
- Those materials are: PIR Sensor, Camera module, ZigBee module which can help us to complete everything.
- We recommend the materials above to help us and InZone to reduce this robbery issues. By create a device monitoring system for security.

Appendix I continued.

APPENDIX J. EXAMPLE OF ONLINE FORUM

2/25/18, 11:11 AM - Messages to this group are now secured with end-to-end encryption. Tap for more info.
2/25/18, 10:38 AM - BLINDED : Hello and welcome to the Whatsapp forum for the InZone- Purdue's Introduction to Basic Engineering. This group enables you to communicate with your colleagues in Azraq, InZone and Purdue. It is an educational forum that allows you to exchange information, discuss course content and learn from each other. Please keep the discussion relevant to the course content and be respectful of each other. Here is a list of guidelines to help us all make this forum a positive and productive resource for learning.

Lets all start by introducing ourselves. My name is BLINDED, Im from BLINDED and work at BLINDED. I'm really looking forward to working with you all to make this course a great success.
2/25/18, 10:41 AM - **BLINDED:** Whatsapp Forum Guidelines Introduction to Basic Engineering
1 This group is for discussions related to the InZone-Purdue Introduction to Basic Engineering course.
2 The forum is primarily intended for students to discuss learning topics, course structure and organisation. Onsite facilitators, online tutors and management will also be present on the forum, but we strongly encourage all students to participate fully in the forum by initiating discussions and conversing with each other.
3 All discussions on the forum must relate to course. Any non-relevant posts will be removed by the administrator.
4 Participants in the group are expected to act respectfully and professionally at all times.
5 Participants are reminded that inappropriate language, images or other media must be kept off the forum.
6 To the extent that is possible, participants should keep all discussions on the public forum, rather than private messaging, to ensure that everyone learns from all discussions.
7 If you change your number during the course, please inform the administrator (BLINDED) immediately, so he can re-add you to the forum.
8 The information discussed in the forum is intended for group members only. Please do not share the content with people from outside the course (unless agreed upon with InZone and Purdue management.
9 If you have any grievances regarding the forum or participants in the forum please email BLINDED h outlining the issue.
10 Make the most of this resource and the opportunity to collaborate with your colleagues by connecting to the forum regularly.

APPENDIX K. EXAMPLE OF INSTRUCTOR JOURNAL

Date: 02/17/2018
Class: Morning ( ) Afternoon (●)
Topic: Class 0 - Introduction
Azraq Camp Author: Claudio Freitas

Preparation:

Provided instructions to students one day before
Students understood instruction (no question before class)
Established contact with facilitators 30 min before class via WhatsApp

Important Notes

Low contact during class time
All students attended the class
I tried to follow-up several times before class to guarantee Blinded nderstood all instructions
I sent messages many times during the class to make sure things were working week
I tried to make my instructions clear so that Hatem could also use the information
He was in the same group. Facilitators from Kakuma were in the WhatsApp group too.

Class time + Challenges

It looks like same problems than last year are happening. Students are facing problems with internet. Students arriving too late.
Shared pictures that are not good to be used for data analysis.
Bog gap to communicate with us to provide feedback. My feeling is that it is hard to manage class and update things via WhatsApp.

Class Results and Follow-Up

The class finished earlier because they lost connection
They shared a few photos that are not clear
They completed 50% of the class planned for that day
All students came to the first class
No questions about what they need to do in class
Once the class was done, I contacted [redacted] to get his impressions about his first day
I've shared my impressions about what I observed and what could be improved
I asked him to share his feelings. He didn't understand the question (feelings?)
He feels happy in doing that. He is concerned about student progress
He thanks me a lot for care so much about him during class time
Other facilitators could see our follow-up and they were very happy for having me as support from Purdue

Appendix K continued.

Wrap-up

Overall, the class worked very well.
I developed an instruction doc that could be used for all facilitators in their first class
In comparison to the previous year, I think I am communicating much better about what they need to do by considering their constraints.

Research keywords

Happy for having support from facilitators
Common problems in terms of lack of internet and students arriving too late
Facilitator concern with student progress showed in the first day

Additional Comments

Since it was the first class, things were running smoothly and we expected that students might need some time until understand the classroom environment and dynamics.

APPENDIX L. EXAMPLE OF FIELD VISIT REPORT

This document contains impressions and observations made during the workshop in Azraq, 2018

Morning, Jan 21

The workshop started a little late. One small group joined in this period. Three females and two males. 2 males were not registered initially. Then, we distributed application forms to them. More people started to come during the morning session. We ended up with six people total. Three female and three male.
BLINDED started the workshop 10:30. BLINDED helped her to translate English to Arabic while speaking. Students were quite while she was speaking. They organized themselves into gender groups where female were in one side and males in another side. While introducing the members of the projects, students didn't ask any questions.
Students are quiet and paying attention to what she said. One student arrived late. Another one came late. One girl left the class. BLINDED agents entered looking for something and it caused a little distraction. Icebreaker discussions were excited. Icebreaker went well.
Former students gave a realistic recall of their experience. It seems that their testimonial especially BLINDED's testimony convinced students
Another student arrived late. One of the girls asked BLINDED and seemed reluctant to ask her question in front of everyone. We collected a significant number of expectations and collected for future analysis. We collected six expectations. Each student wrote one thing. Only one was written in English. All others in Arabic.
Due to lack of time, we skipped this part to the Knex activity.
Students understood the activity and started to work based on the instructions. No questions so far, and they are receiving support from peer-tutors about how to do the activity properly.
After completing the first part, they switched all instructions with other groups. Once the time was over, they compared with the expected picture. No one reproduced exactly like the others wrote instructors. Then, we gave time for them discuss and share their thoughts about what went wrong or not. They shared reasonable arguments.
BLINDED started to talk about course policies. She explained about expectations for this work, workshop, and time availability for the workshop. During this moment, only one female stayed since all others had to leave. She presented the purpose of this course, challenges, motivation to take the course, and the course map.
She asked if they have any questions. One student asked a question about practical applications. The same person asked about future courses. He asked the third question about the course language. He asked the fourth question about the nature of the course material and how it will be distributed.
Another student asked about the course duration. One interesting thing is that once one student started the first question, all others began to ask other questions. BLINDED introduced a little bit about the second class before wrapping up the first day in the morning sessions.

Afternoon, Jan 21

Appendix L continued.

The class started with nine participants. Only one female among these participants. The female came with her daughter. The workshop in the afternoon began 20 minutes late. BLINDED helped the translation. During the morning, BLINDED helped her. She introduced her and BLINDED. No questions from students so far. Two kids attended the session with their parents. The BLINDED guys entered several times disturbing the flow of the course
BLINDED started to introduce the diverse activity. Students were paying attention and didn't ask a question about that. No female in the class. Once BLINDED gave the instructions, they started to work in groups. At this stage, we had three groups divided between 2, 3, and four people per group.
Students gave several feedbacks about their understanding of diversity. They defined diversity as "perfection." Other student stated their perception of diversity, but we didn't understand because he spoke in in Arabic, and no discussion happened after that.
Students were deeply concentrated in the presentation about diversity. BLINDED explained the activity. Students seemed to understand since nobody asked questions. Students seemed to work in teams very well. No questions about the instructions. Even though talk about diversity might raise several questions, they could understand the value and importance of diversity. It was reflected in their answers and ways of working.
BLINDED walked through all groups, and they seemed confident with their analysis.
After times up, BLINDED asked about their answers. One group said that team B came up with a better solution. All teams came up with answers and spoke clearly in Arabic about their arguments. Need clarification in English. Overall, all teams agreed that team with different ages came up with the better solution due to different backgrounds and experiences.
Several problems happened during this activity. First, the correct link should be edge.edx.org. Then, we had to switch from French to English. Then, we had to fix the internet connection on all laptops. They experienced a slow connection when accessing pages and opening videos. After solving that and clarifying possible questions, we moved to the activity. Engineering Practice. Students understood the assignment. They didn't ask questions. They needed more time to write up everything than the morning session. Maybe it happened because there are more people. No questions about the activity until this moment. Some students tried to cheat by looking at other projects. Then, we had to change our strategy to switch projects. Students seem very excited about the next phase of the activity. They are trying to accomplish the best result. For that, they discuss a lot of peers. Overall, the activity worked well, and they enjoyed doing that. BLINDED asked what challenges they experienced and what went well. They discussed fair descriptions, and some almost got the correct shape. However, they still feel the description from other teams for the second phase was the main challenge. When explaining things that could be improved, they cited things that we, in fact, talk about engineering design process about the importance to be very specific, improve communication, and modifying existing models.
Then, BLINDED started to clarify the purpose of the activity and then moved to course policies. While explaining activities, students were very responsive to the questions that BLINDED made. They also were paying attention to what she says. No questions while explaining the course policies. One student asks what if he could not attend the final exam at the end of the course. Then, we clarified that there is no final exam. Only a final project. They asked several times about things related to their presence in the course. We said that we could be flexible, but the motivation to take this course is the most important thing.

APPENDIX M. EXAMPLE OF COURSE CALLOUT

Are you curious about learning and interested in supporting your community?

Course: Introduction to Engineering

Enabling the engineer in you to solve community problems.

Course Objectives

- **Identify local needs** that require an engineering solution
- Practice engineering **problem solving**
- Learn **fundamentals** of electrical engineering, electronics, solar energy and programming
- Develop **professional skills** (communication, ethics, leadership, teamwork, digital literacy)
- After completing this course, students obtain 7.5 US **academic credits** (CEU) from Purdue University.

Introductory Engineering Content

- Delivered in part through an **online platform** (edX), part face-to-face individual and group work
- **Electronic and physical prototyping** tools to practice and conduct experiments
- **Low-cost computing** (introductory programming, Arduino or similar device integration)
- Tailored to the **interests** and projects of the students

What do you need?

- Must be 18 years or over
- Must understand English (Additional materials in other languages)
- At least 4 hours of in-class activities per course week (Expect 2 extra hours in the final 3 weeks)
- Must attend introductory course workshop, interviews and course surveys, team project
- Required to attend at least 75% of the classes (approx. 18 out of 24 classes)
- Curiosity about learning and applying what you learned to support your community

"This training was one of the most important things in my whole life. By its end I am able to plan for my own projects and start implementing them. I am now more powerful, and I have the possibilities to start. People around me call me the engineer. I hope this training opportunity will be available to everyone."
Quote from a learner in the Azraq camp having taken the previous introductory engineering course.

Registration:

Register by completing the short application form and submitting by email to **eng.azraq@gmail.com**

Then, attend the introductory course workshop and afterwards complete the entrance exam.

Contact your local community at this address

Implementing Partners

FORD FOUNDATION · care · UNHCR The UN Refugee Agency · NSF

Academic Partners

PURDUE UNIVERSITY · DEBEER LAB · UNIVERSITÉ DE GENÈVE GLOBAL STUDIES INSTITUTE · INZONE

APPENDIX N. EXAMPLE OF INDEPENDENT PROJECT CALLOUT

Introductory Engineering Course

We are interested in supporting projects that can positively impact the InZone Learning Hub. If you have an idea for an independent project that builds on the engineering skills you have learned and the motivation and knowledge to do so, this a great opportunity.

What are we looking for?

In the first semester of 2018, Purdue University and University of Geneva offered an introductory engineering course where students learned the steps of the engineering design process and how to apply that knowledge towards local problems. In the fall semester, we want to continue to support student ideas from the first course. These can be improved from the first semester or new ideas. *The most important part is that they are actually implemented, not just a proposal.*

Thus, we invite project proposals so that we can better support implementation of your ideas. This is a self-directed learning experience where we will support your group by providing resources and constructive feedback, but you need to coordinate your team for each step.

What are the requirements for this proposal?

- **[Team organization]** At least one member of the group should have credit or participation certificate from the introductory engineering course offered in the first semester of 2018.
- **[File submissions]** Your group should prepare and submit complete project documentation that describes your project plan, updates, and how you intend to convert your idea into something practical, useful, and feasible.
- **[Formatting]** We strongly recommend your team formats the project concept and proposal using tabular, diagrams, and calculations.
- **[Language]** At least one member should be able to communicate in English to keep active connection with online tutors. Documents submitted can be English, French, and Arabic.
- **[Criteria]** Your idea should meet five different criteria: User desirability, economic viability, implementation viability, technical feasibility, and sustainability (Detailed description of these criteria will be provided if your ideas are selected).

What will be your obligations in case we select your project?

In case your project gets approved and selected by our committee, your team needs to meet minimum requirements in order to maintain support throughout the entire project development and implementation.

- Your group will submit reports (following specific templates) on interim due dates describing your project progress.
- Successful projects will be technically supported by the Purdue team to carry out the project, but you will be responsible for implementing the project according to the agreed upon project document, justified budget, and timeframe.
- Students should have the necessary time to carry out the project as a group according to the workplan and will be responsible for coordinating meetings and work.
- Your team should provide online updates regarding progress, needs, or improvements via email, WhatsApp, or any other online media. Check-ins should be weekly, at minimum.
- Depending on the scope of the project, teams may be required to coordinate and consult with specific partners at the camp level. This will be determined at project selection stage.

How to apply?

Please find below the steps that your team should follow to be eligible for this program:

1. Contact Purdue University/University of Geneva by email/WhatsApp to alert them to your interest in applying for this project.
2. Provide the name(s) of the group members, a title of your project, and one paragraph describing the main idea of your project. Please email your description to our team (address available below) by the "Project concept submission" deadline. You may do so before this deadline, and you may get results earlier.
3. Our committee will evaluate your entry. Based on that, we will ask you to submit a more detailed project proposal, which justifies the budget for equipment and helps us understand your specific implementation plans, material needs, and timeline.
4. If you are building off of a project from the first course, be sure to incorporate all of the suggestions you received when you actually build the product.
5. Your team should complete this proposal and submit it via WhatsApp or email.
6. Once we evaluate your project proposal, we will notify your group to let you know if your idea was selected to move forward. If selected, we will continue to work with you through the creation, construction, and implementation, as described above.

Deadlines

Project concept submission: September 30th
Result notification: October 15th
First full project proposal submission: November 1st
Result notification and support for next steps: November 15th

More information:

If you have any question or suggestions, please contact us via email BLINDED
Also, feel free to reach out to us through our InZone facilitators in the camp.

APPENDIX O. EXAMPLE OF INDEPENDENT PROJECT

SLIDE OMITTED DUE TO NAME CONFIDENTIALITY

3S Azraq

3S AZRAQ
Smart Safety System

General Description :

Our project is about keeping the shelter safe especially from fire and gas leaking through using electrical circuits contain sensors connected to alarm devices and monitoring system by Internet , bluetooth or gsm connection .

Appendix O continued.

Our target ***: We seek through our project to protect the lives of the people living in the camp through early warning in case of leakage of gas or fire alarms are activated automatically and quickly, which is easy to fight the fire immediately after its inspection, especially that the UNHCR has distribution of fire extinguishers a short time ago***

We hope that there will not be incident similar to the one you see now.

Project idea :

Over the last 3 years, the camp experienced several fire accidents.

Some of them are children who are left from a short time of the ambience of war , You can imagine the case of shock possible that suffer as a result of fire .

Even got cases of death because of fires in AlZaatri Camp .

In addition , fires destroy the property and personal documentation that are difficult to reclaim it .

Fires in front of eyes can destroy memories wich managed to brought with them .

We verified that shelters are very sensitive to fire, and there is no a safety system to protect our shelters .

Hence the need to help our people in the camp to preserve their lives, memories and documents. Through our course (Introduction to Engineering) we were able to gain the necessary expertise in the search for solutions to this problem

So we believe our project can help to reduce the number of accidents or even incidents .

Appendix O continued.

Research and Generate ideas

3S AZRAQ
Smart Safety System

Engineering design process Which we learned through (Introduction to Engineering) course And we worked on during the preparation of the project .

- ✓ *Need finding (Lack of security systems)*
- ✓ *Problem scoping - Shelters on fire without a good alarm system*
- ✓ *Concept generation/reduction/selection - The project we offer today can provide early warning and allow the user to deal with the fire*

Research and Generate ideas

3S AZRAQ
Smart Safety System

After conducting research among the types of sensors serving the protection project we are planning we have found five types of sensors that can fit our project.

By making a larger and more comprehensive comparison between the selected sensors, we obtained the result that the MQ-5 sensor is more suitable for our project to detect all types of flammable gas than other sensors .

Knowing that all gas sensors of this category are equal in price .

Project sensors information :

MQ-5 : High sensitivity - Fast response - Stable and long life - Detecting concentration scope ： 200-10000ppm

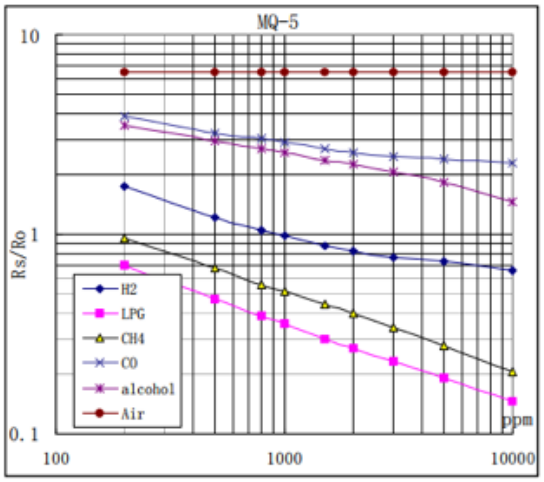
Flame sensor : Detects a flame or a light source of a wavelength in the range of 760nm-1100 nm - Detection distance about 120 cm - Detection angle about 60 degrees, it is sensitive to the flame spectrum .

Appendix O continued.

Research and Generate ideas

Flammable gas sensors	
Model	Target gas
MQ-2	General combustible gas
MQ-4	Natural gas + Methane
MQ-5	LPG, natural gas , town gas, avoid the noise of alcohol and cooking fumes and cigarette smoke
MQ-6	LPG + Propane
MQ-306	LPG + Propane

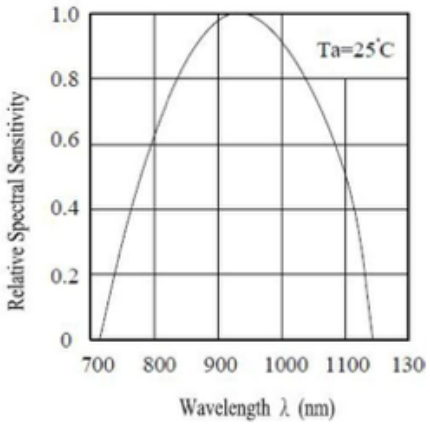
Additional Info about MQ-5 Sensor



sensitivity characteristics of the MQ-5 for several gases. in their: Temp: 20℃、Humidity: 65%、O2 concentration 21% RL=20kΩ Ro: sensor resistance at 1000ppm of H2 in the clean air. Rs:sensor resistance at various concentrations of gases

Appendix O continued.

Additional Info about Flame Sensor



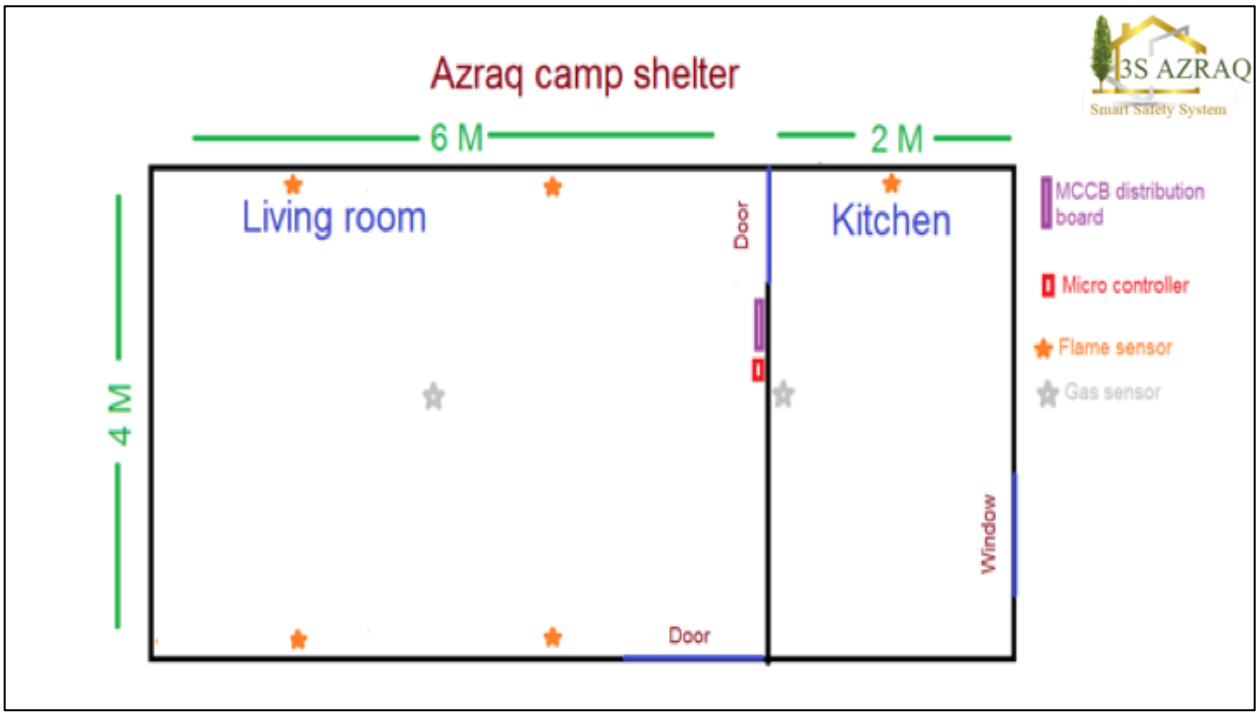
Item	Min	Typical	Max	Unit
Voltage	4.75	5.0	5.30	VDC
Current	/	20	/	mA
Range of Spectral Bandwidth	760	940	1100	nm
Detection range	0	-	1	m
Response Time		15		μS
Operating Temperature	-25	-	85	℃

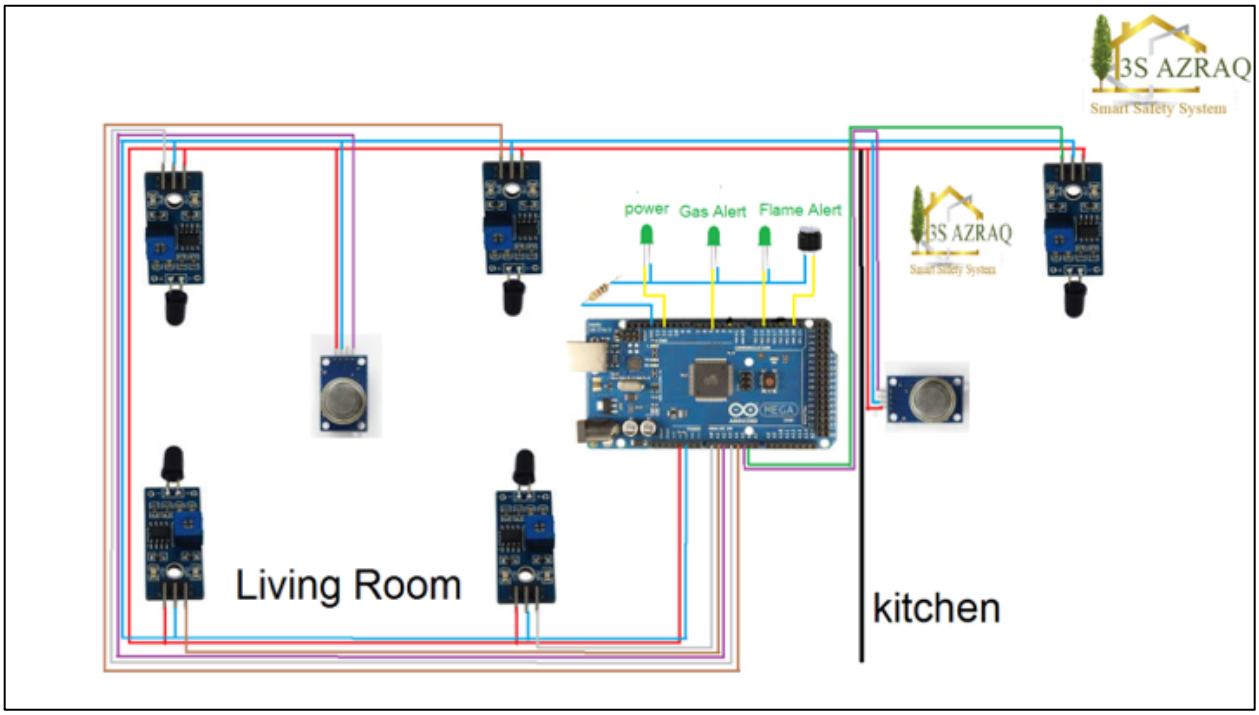
Shelter in Azraq camp

Once the presentation has been completed, we will hand over all studies and plans to the Studies Section of the UNHCR in Azraq camp for reconsideration and approval or propose any amendments or recommended changes.

We hope to optained the necessary approval from the Department of Studies to start implementing the project in one shelter and evaluate the results with them to achieve the ultimate goal of implementing the project in all shelters and securing the lives of camp residents.

Appendix O continued.





Appendix O continued.

The programming code used in the project

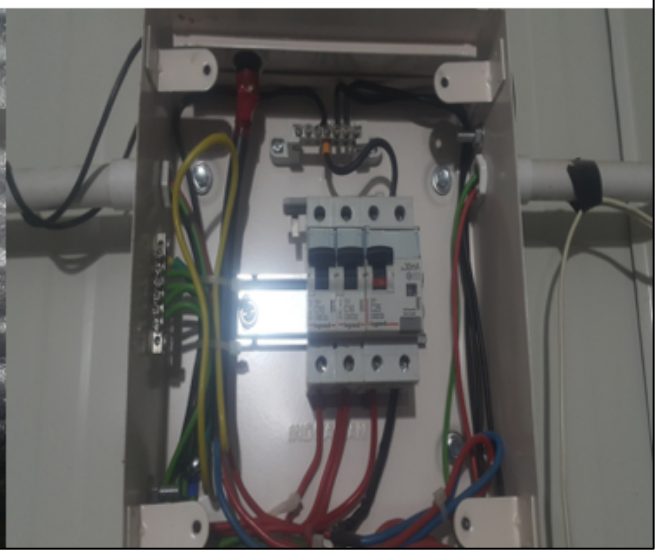
3S AZRAQ
Smart Safety System

```
#include<SoftwareSerial.h>
int sensorPin = A0; //
int sensorValue = 0; //
int led = 4; //
int buzzer = 12; //
int led_pin=2;
int analog_pin=A4;
void setup() {
pinMode(2, OUTPUT);
pinMode(4, OUTPUT);
pinMode(3,OUTPUT);
pinMode(5, OUTPUT);
Serial.begin(9600);
}
void loop()
{
Serial.println("Welcome to 3S Azraq");
digitalWrite(5, HIGH);
  delay(100);
sensorValue = analogRead(sensorPin);
Serial.println(sensorValue);
if (sensorValue < 400)
{
Serial.println("Fire Detected");
Serial.println("LED on");
digitalWrite(4,HIGH);
digitalWrite(3,HIGH);
delay(1500);
}
```

```
Serial.println("Fire Detected");
Serial.println("LED on");
digitalWrite(4,HIGH);
digitalWrite(3,HIGH);
delay(1500);
}
digitalWrite(4,LOW);
digitalWrite(3,LOW);
delay(sensorValue);
int temp;
  temp=analogRead(analog_pin);
  if(temp>300)
  {
    Serial.println("dangerous!!");
    digitalWrite(2,HIGH);
    delay(1500);
    digitalWrite(2,LOW);
    delay(250);
    digitalWrite(3,HIGH);
delay(1500);
  }
  else
  {
     Serial.println("No dangerous!");
     digitalWrite(2,LOW);
     delay(250);}
     digitalWrite(3,LOW);
delay(250);
}
```

MCCB distribution board

3S AZRAQ
Smart Safety System



Appendix O continued.

Implementation Plan

- ✓ *engineering design process*

  Need finding / Problem scoping / Concept generation (December 2017)
- ✓ *Build the prototype and display it (Mid-January 2018)*
- ✓ *Application of the entire project within shelter in the camp (End of February 2018)*
- ✓ *Conduct assessment and several tests under various working conditions*

  (During the first half of March)
- ✓ *Add monitoring system and means of communication*

  (internet - gsm – bluetooth) (The second half of March)
- ✓ *Conducting tests and evaluation by beneficiaries (dueing April)*

ITEM REQUEST

Materials	COUNT	Total price
Arduino mega 2560	1	13JD
Flame sensor module	5	20JD
MQ-5 Gas Sensor module	2	10JD
PCB (Double-side Prototype PCB Universal Printed Circuit Board Kit 5pcs	1	5JD
LEDS(WHITE-BLUE-RED-GREEN)	10	1JD
Power supply Adapter 9V-1A	1	4JD
Project box 18.12 cm	1	6JD
4 Pin connector wire extension	3	3JD
wires(20cm Male TO Female 40Pin Solderless Jumper Breadboard Wires)	1	3JD
Active Buzzer 5V	2	2JD
Total price		67 JD

The amount of 10 JD will be added in Phase 6

Appendix O continued.

Why 3S Azraq is better

3S AZRAQ
Smart Safety System

One of the types of gas sensors in the market coast 35 JD and the same purpose of our project, but we need to be sensitive to be able to cover the kitchen area in addition to the living room , Simple calculation

Shows that we need 70 JD to cover kitchen and living room area .

In search for flame sensors in the market, we could not find any flame sensors .

This means that the cost of buying only two gas sensors (ready to use) from the market equals the cost of implementing our entire project ,

But our design contains flame sensors also can connect to Internet or Bluetooth or any other modules .

One of the gas leak detectors available on the market

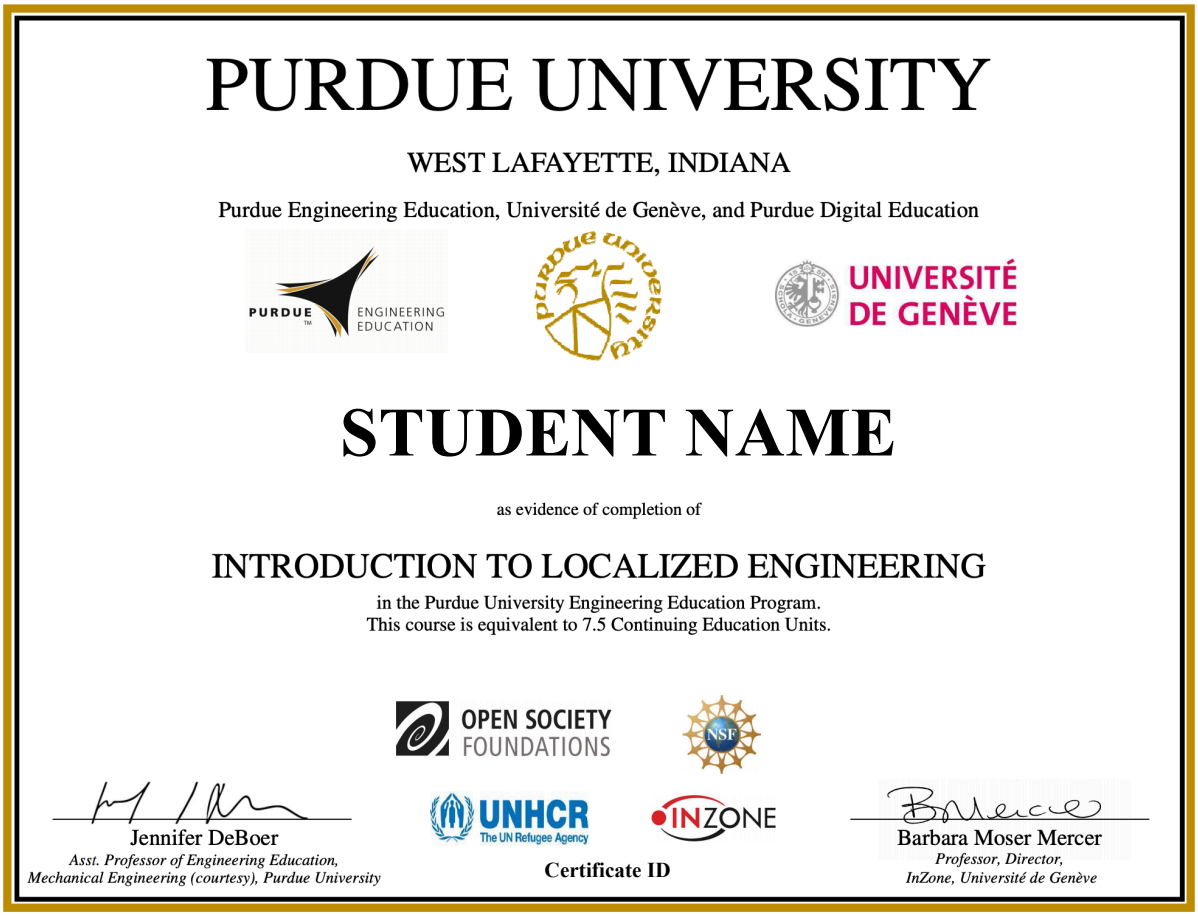
3S AZRAQ
Smart Safety System

- Electronics stores in Jordan have all these materials , prices according to these stores
- http://www.wasfieh.com/
- http://www.elektropio.com/
- http://en-geniuses.com
- More information about main component :
- https://store.arduino.cc/usa/arduino-mega-2560-rev3
- https://store.arduino.cc/usa/arduino-nano
- https://www.osepp.com/electronic-modules/sensor-modules/60-flame-sensor-module
- https://www.waveshare.com/mq-5-gas-sensor.htm
- Sources :

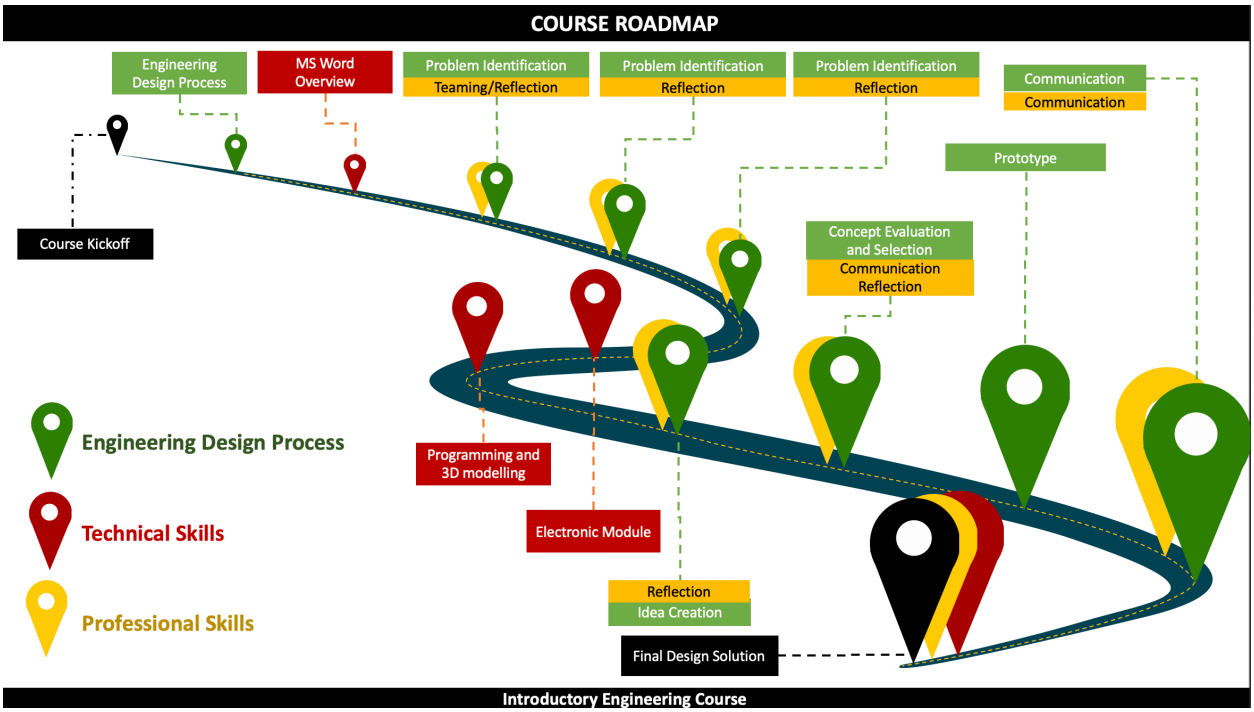
- https://www.olimex.com/Products/Components/Sensors/SNS-MQ135/resources/SNS-MQ135.pdf
- https://www.pololu.com/file/0J309/MQ2.pdf
- https://www.sparkfun.com/datasheets/Sensors/MQ-3.pdf
- https://www.parallax.com/sites/default/files/downloads/605-00009-MQ-5-Datasheet.pdf
- https://www.sparkfun.com/datasheets/Sensors/Biometric/MQ-7.pdf
-
- Another option we can to add :
- 1: DHT22 Temperature and humidity sensor module
- 7 JD
- 2: HC-SR501 Human body Pyroelectric Infrared sensor PIR (Motion sensor)
- 3 JD
- 3: MQ-135 air quality sensor
- 5 JD

Appendix O continued.

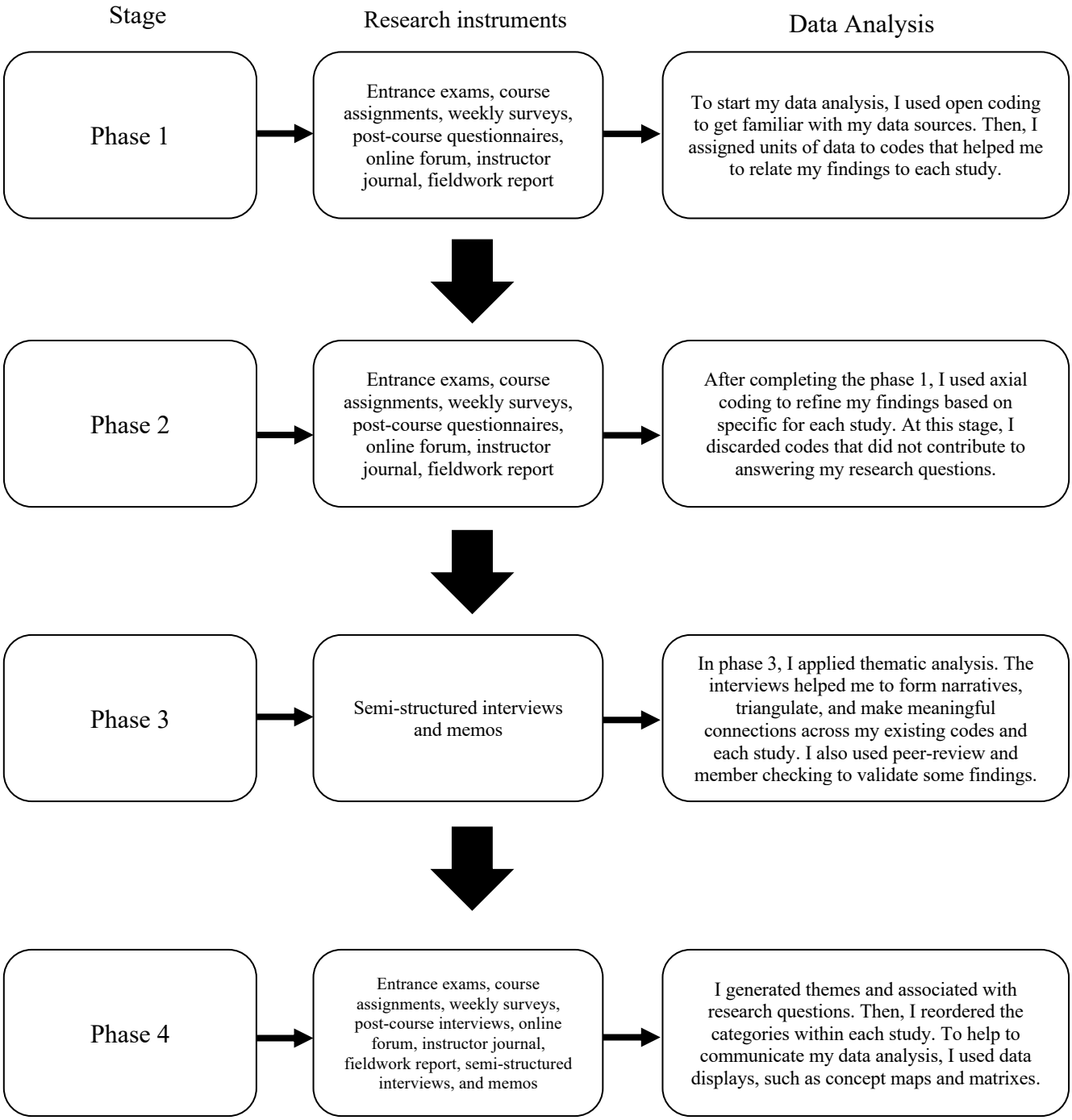
APPENDIX P. EXAMPLE OF CERTIFICATE



APPENDIX Q. COURSE ROADMAP



APPENDIX R. OVERALL PROCESS OF ANALYSIS



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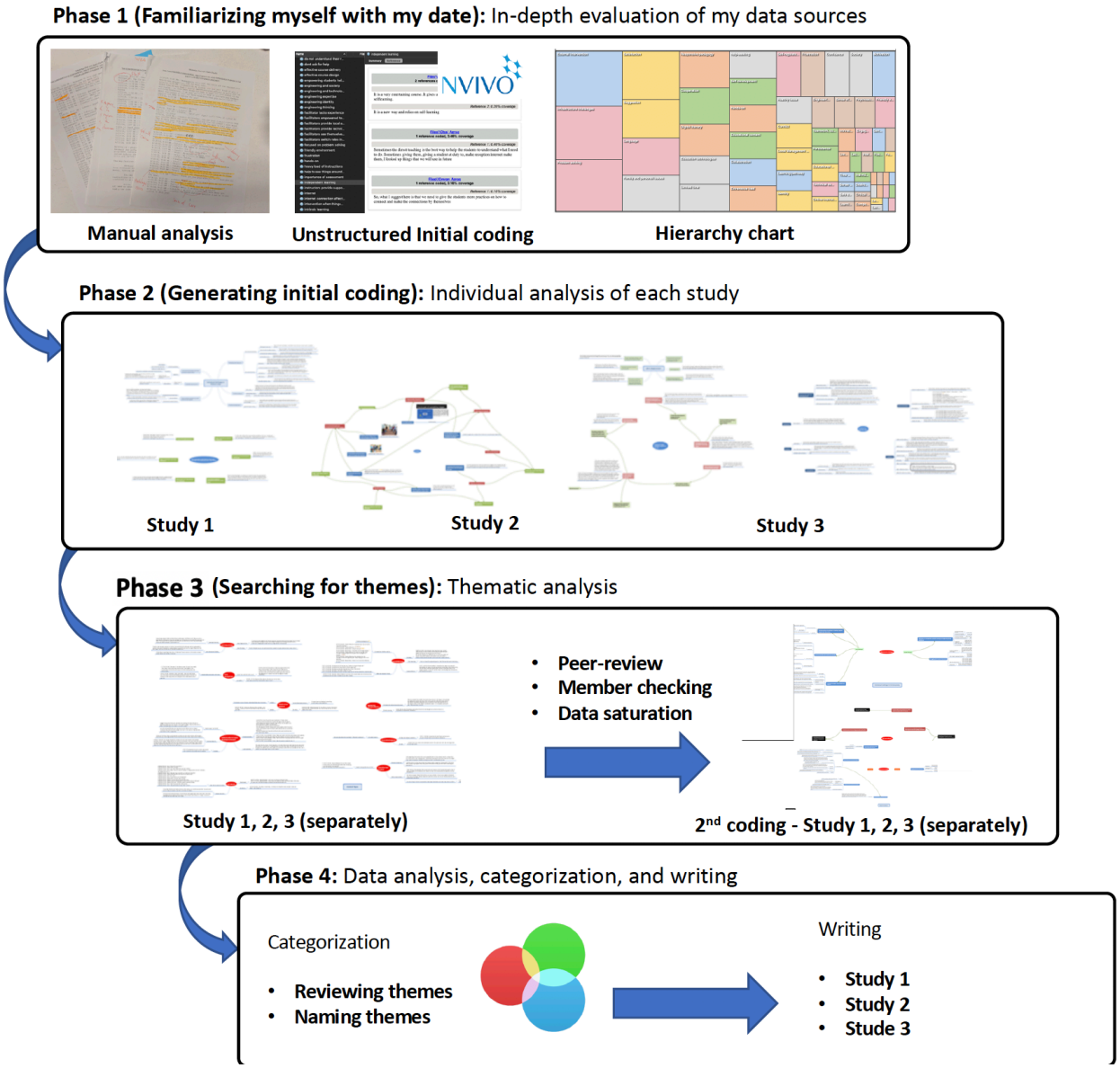
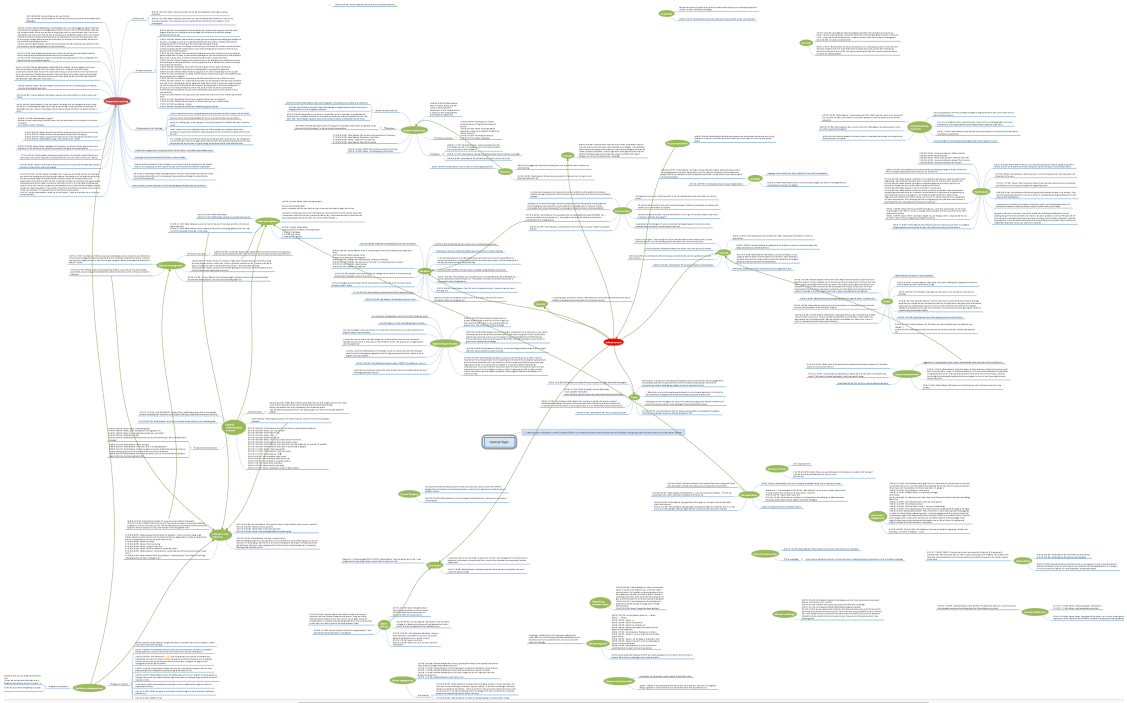
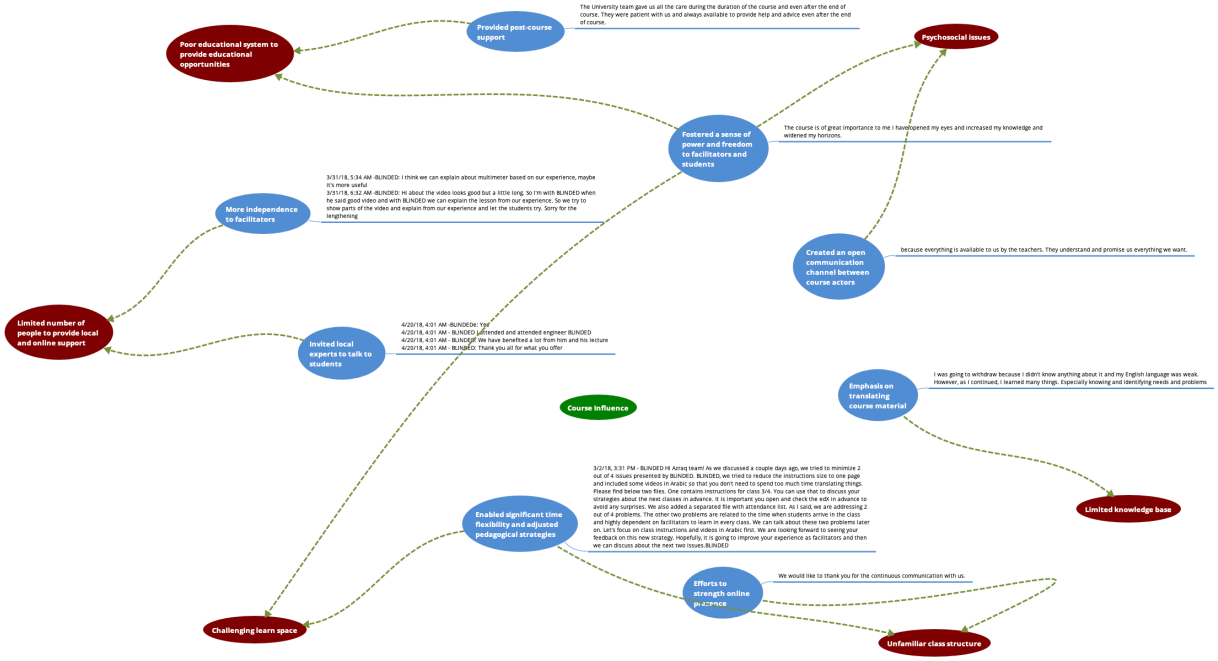


APPENDIX S. EXAMPLES OF THEMES IN AZRAQ





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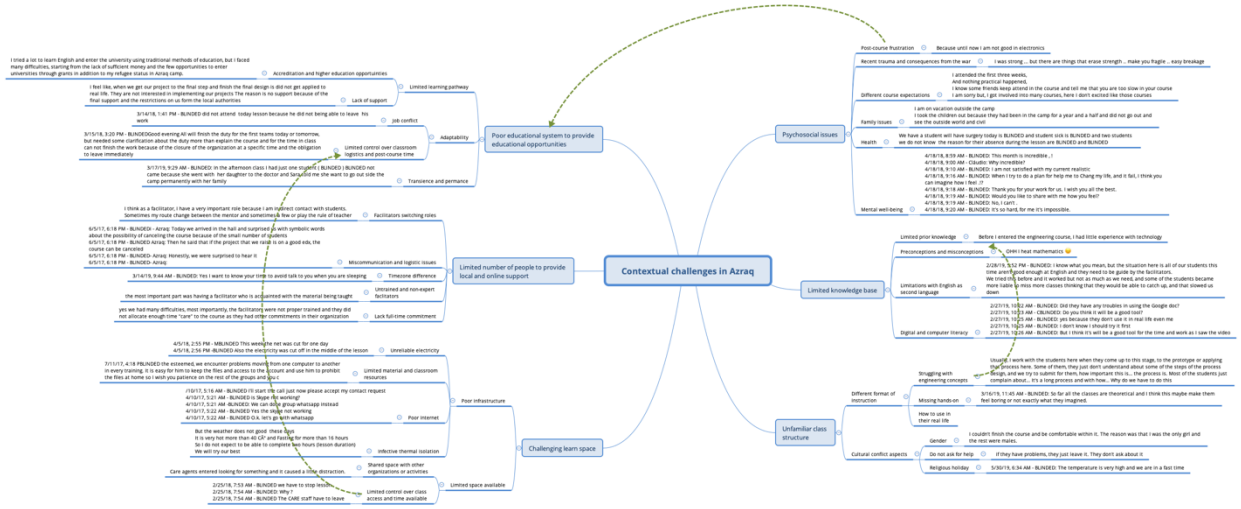

Contextual Challenges **Azraq**

Infrastructure
- Limited/Slow Internet
- Unreliably/No electricity
- Harsh weather
- Shared Physical space
- Technical problems

Learning Pathway
- Lack of opportunities
- Lack of funding

Psychosocial
- Lack of motivation
- Course frustration
- Family priorities
- Recent emotional trauma

Knowledge base
- Misconceptions
- Poor English
- Limited prior knowledge
- Limited digital and computer literacy

Local management
- Constant rotation
- Time restriction
- Job conflict

Limited local support
- Lack local expert
- Switching roles
- Timezone difference
- Miscommunication
- Logistic issues

Sociocultural aspects
- Do not ask for help
- Religious celebration
- Gender issues

Class structure
- Missing hands-on practice
- Different format of instruction
- Different expectations
- Limited course access

APPENDIX T. PUBLICATIONS

DeBoer, J., Radhakrishnan, D., & Freitas, C. C. S. (under review). *Localized Engineering* in Displacement: An Alternative Model for Out-of-School Youth and Refugee Students to Engineer their own Solutions for their own Communities. Advances in Engineering Education

C. C. S. de Freitas and J. DeBoer, "A Mobile Educational Lab Kit for Fragile Contexts," 2019 IEEE Global Humanitarian Technology Conference (GHTC), Seattle, WA, USA, 2019, pp. 1-7.

Freitas, C. C. S., Beyer, Z., & DeBoer, J. “EngStarter: An Open-Hardware and IoT Integrated Education Kit for Increasing Community-Developed Solutions”, 8th Research in Engineering Education Symposium (REES), Cape Town, South Africa, July 2019

Olayemi, M., Freitas, C. C. S., Radhakrishnan, D., Dridi, M. A. & DeBoer, J. “Improving course retention rates in engineering education in refugee settings: Lessons from two case studies”, 8th Research in Engineering Education Symposium (REES), Cape Town, South Africa, July 2019

FREITAS, C. C. S., Qureshey, J., Beyer, Z. J., DeBoer, J. (2018). Designing an Engineering Classroom in a Democratic Learning Space in the Azraq Refugee Camp. (Poster Presentation) 2018 Illinois Indiana ASEE Section Conference, West Lafayette, IN.

FREITAS, C. C. S., Beyer, Z. J., Yagoub, H. A. A., DeBoer, J. (2018). Fostering Engineering Thinking in a Democratic Learning Space: A Classroom Application Pilot Study in the Azraq Refugee Camp, Jordan. 2018 ASEE Annual Conference and Exposition, Salt Lake City, UT.

VITA

Claudio Freitas [First and Last name]

(Pronouns: he/him/his)

EDUCATION

Doctor of Philosophy in Engineering Education [GPA: 3.88/4] May 2020
Purdue University, USA

Dissertation: Understanding Engineering Education in Displacement: A Qualitative Study of "Localized Engineering" in Displacement

- **Certificate in Qualitative Research**, Purdue University (2020)
- **Summer School in Higher Education in Emergencies**, InZone – University of Geneva (2019)

Master of Science in Electrical Engineering [GPA: 3.83/4] May 2014
The University of Campinas, Sao Paulo, Brazil

Thesis: A Study of Palmprint Recognition Using Principal Component Analysis and Local Adaptive Thresholding

Bachelor of Science in Mechatronics [Performance: 7.3/10] December 2011
Higher Education Institute of Amazonia, Belem, Brazil

HONORS AND AWARDS

- 1st Best Idea – Innovate for Refugees Competition (MIT Enterprise Forum) Jordan, Jan 2019
- 1st Best Paper - Duncan Fraser Award (Research in Engineering Education Symposium) South Africa, Jul 2019
- 2nd Best Project – Data of Things Challenge (Giddy Challenge) USA, Feb 2018
- People's Choice Award – Best Poster (Dawn or Doom Conference) USA, Oct 2017
- Young Scientist Award (International Society for Engineering Education - IGIP) Russia, Jul 2013
- Leadership Award (Ibero-American Science and Technology Education Consortium) Colombia, Sep 2013
- Future Entrepreneur (Redemprendia) Spain, Dec 2013
- 1st Place – Formula SAE Electric Competition (Society of Automotive Engineers) USA, Jul 2013
- 1st Place – Formula SAE Electric Competition (Society of Automotive Engineers) Brazil, Dec 2012
- 1ST Best Student Initiative for Engineering Students (Cengage Learning) Portugal, Sep 2011

GRANTS/FELLOWSHIPS

- Graduate Student Travel Award (Susan Bulkeley Butler Center for Leadership Excellence) USA, Jul 2019
- Visiting Graduate Research Program (Santander Bank Foundation) Brazil, Oct 2012
- Master's Degree Fellowship (Brazilian Council for Scientific Development) Brazil, Feb 2012 - May 2014
- Undergraduate Research Fellowship (Para Research Foundation) Brazil Oct 2010- Oct 2011

RESEARCH EXPERIENCE

Graduate Research Assistant July 2016 - Present
Department of Engineering Education, Purdue University, USA

- Designed and developed a blended course focused on engineering design and community development for tertiary engineering students in refugee camps (Azraq camp, Jordan and Kakuma camp, Kenya)
- Led the development of a low-cost educational tool to support and enhance engineering education in fragile communities, such as slums and refugee camps.
- Collaborated and contributed to a multidisciplinary project aimed at understanding faculty adoption of new instructional pedagogies in higher education institutions using qualitative methods.

Graduate Research Assistant

Laboratory of Visual Communications, University of Campinas, Brazil Feb 2012 – May 2014

- Contributed to multidisciplinary projects aimed at developing algorithms and systems focused on image processing and digital communication.
- Collaborated with faculty and fellow graduate students across departments to co-create workshops and seminars to disseminate our research in the department of electrical engineering.

Visiting Graduate Researcher

Department of Electrical Engineering, The University of New Mexico, USA Jan 2013 – May 2013

- Developed new features for medicinal devices and image recognition tasks by improving the recognition accuracy from 86% to 94%.
- Investigated and developed methods to improve component selection and algorithm (sensing) development through image processing techniques.

Undergraduate Researcher

Department of Mathematics and Statistics, Higher Education Institute of Amazonia, Brazil Oct 2010 – Oct 2011

- Developed neural network algorithms using C/C++ for optical character recognition.
- Designed and execute small-scale testing to validate pattern recognition algorithms.

TEACHING AND MENTORING EXPERIENCE

Course Designer and Instructor 2017 - 2019

Introductory Engineering Course in Refugee Camps

- Prepared classes, lectures, assessment, and class activities focused on engineering design and society.
- Instructed engineering classes in a blended learning course in two refugee camps in Jordan and Kenya for students aged from 18 to 51 years old from 2017 to 2019.
- Created and graded course through a responsive and formative assessment to ensure students understood the material and stayed on track.
- Integrated multimedia strategies and used a variety of educational technologies to enhance the pedagogical approach.

Graduate Mentor 2016 - 2019

- Mentored 7 undergradute student in data collection and analysis, coding, circuit development, and lessons plan development.
- Guided students through the process of preparing and presenting research findings.

Course Assistant

Gifted Education Research and Resource Institute Summer Camp Summer 2018

- Collaborated with instructors to prepare classes and engineering design activities for gifted students aged from 8-10 years old from across the camp and around the world.
- Explained challenging engineering concepts for young students (grades 7 – 8).

INDUSTRY EXPERIENCE

Senior Product Engineer

Fiat Chrysler Automobiles, Brazil Jul 2014 – Jun 2016

- Provided Hardware in the Loop (HIL) capability in Latin America across engine management, transmission, and driveline teams in the US and Italy.
- Recruited and mentored 4 interns on global testing procedures and capabilities.
- Developed mathematical models, data acquisition, and analysis of powertrain systems.
- Programmed test scripts and test procedures.
- Defined global test automation methodologies across different company sites in the US, Italy, and Brazil.

Research & Development Engineering Intern

Hitachi Automotive Systems Americas, Inc. – Farmington Hills, USA Oct 2013 – Apr 2014

- Developed a platform for fast prototyping using Simulink Embedded Coder and Target Link.

- Programmed Hardware in the loop system for automotive simulation purposes.
- Implemented real-time multiprocessors based on the co-simulation technique.

Electrical Engineering Intern
GMFREEZER Climate Services – Belem, Brazil Mar 2010 – Dec 2011
- Developed and maintained an e-commerce website.
- Designed and analyzed electrical projects from industry, church, and residences.
- Programmed controller systems for energy consumption optimization.

PUBLICATIONS/PRESENTATIONS

Journal Publications
- Evenhouse, D., Zadoks, A., **FREITAS, C. C. S.,** Patel, N., Kandakatla, R., Stites, N., Deboer, J. (2018). Video coding of classroom observations for research and instructional support in an innovative learning environment. Australasian Journal of Engineering Education, 23(2), 95-105.
- **FREITAS, C. C. S.,** IANO, Y., (2014). A Study of Palmprint Recognition using PCA and Local Adaptive Thresholding. Cyber Journals: Multidisciplinary Journals in Science and Technology, Vol. 4, Issue 2.
- **FREITAS, C. C. S.,** LARICO, R. F., HIGA, R. S., IANO, Y. (2012) Home Automation: Current Scenario & Future perspectives. Science and Technology Magazine, [S.l.], v. 15, n. 26. ISSN 2236-6733. – Published in Portuguese.

Works in Progress
- Localized Engineering in Displacement: An Alternative Model for Out-of-School Youth and Refugee Students to Engineer their Own Solutions for Their Own Communities, Advances in Engineering Education. *Article manuscript submitted and under review.*
- A Case Study of the Design and Delivery of an Engineering Design Course in a Jordanian Refugee Camp: A Descriptive Course Implementation. ***First Author.*** *Article manuscript in progress, to be submitted for publication in spring 2020.*
- A Case of an Engineering Design Course in a Kenyan Refugee Camp: Contextual Challenges and Educational Implications. ***First Author.*** *Article manuscript in progress, to be submitted for publication in spring 2020.*
- Engineering and Community Development: Lessons from a Localized Engineering Education for Displacement in Jordan and Kenya. ***First Author.*** *Article manuscript in progress, to be submitted for publication in summer 2020.*
- A Faculty Perspective on Examining the Adoption of Active, Blended, and Collaborative Learning in a Mechanical Engineering Course in Colombia. ***First Author.*** *Article manuscript in progress, to be submitted for publication in summer 2020.*

Conference Proceedings (full papers and posters)
- **FREITAS, C. C. S.,** and DeBoer, J., "A Mobile Educational Lab kit for Fragile Contexts", Proceedings of GHTC 2019, the 9th IEEE Global Humanitarian Technology Conference, Seattle, USA, October 2019.
- **FREITAS, C. C. S.,** Beyer, Z., and DeBoer, J., "EngStarter: An Open-Hardware and IoT Integrated Education Kit for Increasing Community-Developed Solutions", Proceedings of REES 2019, the 8th Research in Engineering Education Symposium, Cape Town South Africa, July 2019.
- Olayemi, M., **FREITAS, C. C. S.,** Radhakrishnan, D., Dridi, M., and DeBoer, J., "E Improving course retention rates in engineering education in refugee settings: Lessons from two case studies", Proceedings of REES 2019, the 8th Research in Engineering Education Symposium, Cape Town South Africa, July 2019.
- **FREITAS, C. C. S.** (2018). Social Empowerment through Engineering Education in Developing Countries. 2018 World Engineering Education Forum - Global Engineering Deans Council (WEEF-GEDC), 1-5.
- **FREITAS, C. C. S.,** Beyer, Z. J., Yagoub, H. A. A., DeBoer, J. (2018). Fostering Engineering Thinking in a Democratic Learning Space: A Classroom Application Pilot Study in the Azraq Refugee Camp, Jordan. Paper submitted and accepted at the 2018 ASEE Annual Conference and Exposition, Salt Lake City, UT.
- **FREITAS, C. C. S.,** Qureshey, J., Beyer, Z. J., DeBoer, J. (2018). Designing an Engineering Classroom in a Democratic Learning Space in the Azraq Refugee Camp. (Poster Presentation) 2018 Illinois Indiana, ASEE Section Conference, West Lafayette, IN.
- **FREITAS, C. C. S.,** Evenhouse, D.G, Patel, N.G, Zadoks, A., DeBoer, J., Berger, E. J., and Rhoads, J. F., "Development of a video coding structure to record active, blended, and collaborative pedagogical practice",

Proceedings of REES 2017, the 7th Research in Engineering Education Symposium, Bogota Colombia, July 2017.

- KANDAKATLA, R., PACKHEM, J., RADHAKRISHNAN, D., DELAINE, D**., FREITAS, C. C. S.,** Insight to Global Engineering Challenges: Study and Analysis. In: SEFI 2014 - 42nd Annual Conference, 2014, Birmingham.
- **FREITAS, C. C. S.,** FIGUEIREDO, D. A., IANO, Y., The inclusion of Extracurricular Activities and Student Competitions in the Curriculum Structure for Engineering Education: Experience Based on the Brazilian Reality. In: 16th International Conference on Interactive Collaborative Learning and 42nd International Conference on Engineering Pedagogy, 2013, Kazan.
- **FREITAS, C. C. S.,** LARICO, R. F., IANO, Y., A study of face recognition using PCA based on spacial features modifications In Congresso de Matemática Aplicada e Computacional Centro Oeste, 2013, Published in Portuguese
- **FREITAS, C. C. S.,** LARICO, R. F., IANO, Y, A study of performance using PCA and pattern recognition under illumination change. In VIII Workshop de Visão Computacional, 2012, Goiânia. – Published in Portuguese
- **FREITAS, C. C. S.,** LARICO, R. F., IANO, Y., Proposal of a multibiometric system using face and gesture recognition. In Congresso de Matemática Aplicada e Computacional - Nordeste, 2012, Natal. Anais do CMAC, 2012. – Published in Portuguese
- **FREITAS, C. C. S.,** PEREIRA, C. E., FARIAS, V. J. C., SOUSA, C. M., MESQUITA, B. D. R., SBA Jovem - Student Chapter of the Brazilian Automation Society: A New Approach to the Education of Control Engineering in Brazil. In: 18th World Congress of the International Federation of Automatic Control (IFAC), 2011, Milan. World Congress: Proceedings of the 18th IFAC World Congress, 2011, 2011.
- **FREITAS, C. C. S.,** MESQUITA, B. D. R., Using Matlab as a Tool for the Teaching of Nonlinear Systems in Engineering: The Case of the Inverted Pendulum In Dynamics Days South America - International Conference on Chaos and Nonlinear Systems, 2010, São José dos Campos. Program and Abstract Books, 2010.
- **FREITAS, C. C. S.,** FARIAS, V. J. C., Representações Estudantis de Sociedades Científicas como Forma de Promover e Integrar Estudantes e a Engenharia In INTERTECH 2010 International Conference on Engineering and Technology Education, 2010, Ilhéus. Book of Abstracts, 2010. – Published in Portuguese.
- **FREITAS, C. C. S.,** MESQUITA, B. D. R., PEREIRA, C. E., FARIAS, V. J. C., DEBOER, J., DELAINE, D., Engineering education development: Approaches based on experiences and observations. In: V CONNEPI, 2010, Maceio. Anais do V CONNEPI, 2010. – Published in Portuguese.
- **FREITAS, C. C. S.,** FIGUEIREDO, D. A. , MESQUITA, B. D. R. , ANDRADE, R. V. C. S. , FARIAS, V. J. C., Development of a low-cost device for temperature monitoring. In: V CONNEPI, 2010, Maceio. Anais do V CONNEPI, 2010. – Published in Portuguese.
- **FREITAS, C. C. S.,** MESQUITA, B. D. R., Methods and tools used in digital image processing: monochromatic applications. In: IV Congresso de Pesquisa e Inovação da Rede Norte e Nordeste de Educação Tecnológica - IV CONNEPI - 2009, 2009, Belém. Anais do CONNEPI, 2009. – Published in Portuguese.

Workshop/Conference Chair

- 10th Global Student Forum, Dubai (Global Chair) 2014
- 9th Global Student Forum, Colombia (International Chair) 2013
- 8th Global Student Forum, Argentina (Technical Chair) 2012
- 2nd Automation and Technology Student Week, Brazil (National Chair) 2010
- 1st Automation and Technology Student Week, Brazil (Regional Chair) 2009

Invited Talks

- Speaker: Engineering Education in Displacement (Virginia Tech) 2019
- Workshop facilitator: Smart Cities and Peace Engineering (World Engineering Education Forum) 2018
- Speaker: Student Voice in Engineering Education (XVII ISTEC General Assembly) 2011
- Speaker: International Student Community in Engineering Education (Intergeneral Panel Forum) 2011
- Speaker: Connecting Engineering Students Around the World (Student Forum of Engineering Education) 2011

Conference Reviewer

- Frontiers in Education Conference, California, USA 2018
- American Society in Engineering Education Conference, Ohio, USA 2017
- World Engineering Education Forum, Florence, Italy 2015
- Brazilian Technology Symposium, Campinas, Brazil 2015

PROFESSIONAL SKILLS

- Languages: Portuguese (Native) & English (Excellent)
- Software package: nVivo, STATA, AutoCAD, MS Project, Corel Graphic Suite, Adobe Photoshop, MS Office,
- Programming: C/C++, Python, HTML & CSS, SQL, PHP, Matlab & Simulink, and R.

UNIVERSITY/PROFESSIONAL SERVICE

Outreach Coordinator 2019-2020

American Society of Engineering Education (ASEE) Student Chapter, Purdue University

- Established partnerships between different engineering departments across campus.
- Collaborated with faculty and fellow graduate students to organize seminars and workshops on campus.
- Participated in regular meetings to discuss new policies and strategic plans for our group.

INEE Tech Task Team Member 2019-2020

Inter-Agency Network for Education in Emergencies (INEE).

- Collaborated with multidisciplinary across the world to identify existing opportunities across institutions to support our global initiatives to advance technology tools in fragile settings.
- Proposed webinars, exchange, and networking activities to evaluate tech initiatives and gaps in education programs running in emergencies.

President Aug 2010 – Dec 2014

Student Platform for Engineering Education Development (SPEED)

- Led a global student organization that functions as an interdisciplinary network of engineering students.
- Served as Outgoing Contest Officer and Internal Affairs Officer.
- Managed global and multicultural teams over ten countries.
- Organized global conferences (Singapore, Portugal, Argentina, Colombia, Dubai, India).
- Managed global challenges in partnership with global institutes.
- Trained engineering students through global events related to global engineering, leadership, and engineering education.

Powertrain Member Jul 2012 – Jun 2013

Unicamp Formula SAE Electric Team

- Worked in a team of engineering students to build a high-performance electric car.
- Conducted, designed, and assembled telemetry systems and control systems.
- This project won the first prize twice in Brazil (2012/2013), and the first prize in the USA in 2013.
- Finalist in a national competition among traditional automotive companies, such as BMW, Ford, Chevrolet, and Hyundai.

President & Co-Founder Feb 2009 – Oct 2011

Student Chapter of the Brazilin Automation Society (SBA Joem)

- Served as co-founder and president in the national committee hooked to Brazilian automation society.
- Facilitated national events and workshops.
- Lectured short courses related to image processing and artificial intelligence.
- Won the first prize in global competition as the best initiative for engineering students promoted by CENGAGE Learning.
- Managed different teams from several states.
- Conducted partnerships between SBA Jovem and industry.

PROFESSIONAL MEMBERSHIP

- Institute of Electrical and Electronics Engineers (IEEE)
- Society for Social Studies of Science (4S)
- ASEE (American Society for Engineering Education)
- INEE (Inter-Agency Network for Education in Emergencies)