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Abstract approved:

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Shane A. Brown

Student engagement in a course plays a vital role in a student's ability to process and construct knowledge. Student engagement research has investigated how students engage in and out of the classroom on a macro scale, through observation and survey data collection of large student populations, which lack focus on the individual student and the influence of context regarding their engagement in a course. This thesis includes one manuscript that explores how students engage in a particular context both in and out of class using descriptive and interpretive case study analysis. Qualitative data was collected through frequent semi-structured interviews with seven student participants enrolled in six different Science, Technology, Engineering, and Mathematics (STEM) courses at a single institution. The results captured a broad range of student engagements in and out of the classroom, which were unique to the student and the context. Understanding how and why students engage in a course allows educators to be proactive towards curriculum development centered about student learning, and reflective in the ways that they are facilitating student learning.

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Student Engagement: Exploring How and Why Students Engage In- and Out-of-Class

by
Jason J. Pascoe

A THESIS

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APPROVED:

Major Professor, representing Civil Engineering

Head of the School of Civil and Construction Engineering

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Jason J. Pascoe, Author

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CONTRIBUTION OF AUTHORS

Jason J. Pascoe conducted all of the participant interviews, led the interpretation of participant engagements, and wrote majority of the contents documented in this thesis. Dr. Shane A. Brown and Dr. Nicole P. Pitterson both helped organize and revise Chapters 1 and 2.

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Chapter 1 – Introduction

1.1 Research context

Over 20.5 million students were expected to enroll in United Stated postsecondary institutions as of fall 2016 [1]. Over half of these students attend full-time in hopes of learning practical concepts and practices that can be utilized in their profession. Researchers believe that to develop the skills necessary to transfer knowledge from one domain to the next classrooms should foster student engagement. It can therefore be argued that when students interact with the course material and their peers their level of engagement contribute significantly to their academic success and conceptual understanding. From the time these students awake in the mornings they may have interacted with roommates, friends, or family members before attending class. While in class, students could engage with course material by following along with visual and oral presentations, in class discussions and activities, and interaction with the instructional team and their classmates. As they leave class that day they are likely to have been given an assignment to complete outside of class, due by the same time next week. Outside of class students face the struggle of balancing extracurricular activities, their social and personal lives, and their academic work. Over time, students begin to form relationships with their peers enrolled in the same courses, those that share similar interests or instructors that may enrich their academic, social, and personal lives. Student engagement outside of the classroom may take the form of individual or cooperative studying, discussion, completion of coursework, or teaching and learning. As students conclude their coursework for the day, they return to their roommates, friends, and family to begin anew. The journey of academic success and the completion of a postsecondary degree requires large quantities of time and energy, and the degree of engagement with the university is influential on student success.

The cornerstone of the college experience is courses and curriculum, and engagement with these is also influential on students' academic success. However, there is a lack of research investigating how and why students engage both inside *and* outside of the classroom that utilizes in-depth research methodologies. This study will contribute a broader understanding of how students engage with a course, and how engagement changes in a particular context.

Previous research on student engagement emphasizes the value of social interaction and student participation in school-related activities [2]–[5]. As students become integrated with the institution, they are more likely to stay committed to achieving academic success and persist [4]. Additionally, Pascarella and Terenzini [6] discuss the changes in communicative, cognitive and reasoning, psychosocial, and general quantitative skills within students that are enrolled in college as opposed to those not in college. Both significant and insignificant changes were found to be dependent upon the individual student, and their perception of engagement in a course. However, even though the value of student engagement is known, little has been done to understand how and why students engage holistically in a course. Further investigation of this topic can be used by educators to iterate course curriculums to better promote student learning and engagement.

1.2 Research questions

The manuscript presented in Chapter 2 of this document poses two research questions of investigation. These research questions include:

1. How do students engage in a course?
2. How does social engagement relate to individual characteristics, and behavioral, cognitive, and emotional engagements within a particular context?

1.3 Structure of the thesis

The first chapter of this thesis begins by presenting the ways in which a student may engage with their education, and the value of related research conducted prior to this study. Research questions and the format of the thesis are outlined shortly afterwards. Chapter 1 concludes with a description of the research performed, with the definitions of terminology commonly used throughout the document. Chapter 2 is a manuscript that will be submitted to the peer-reviewed engineering education International Journal of Engineering Education (IJEE). In this chapter, a review of literature, methodology, summary of analysis, the discussion of findings, conclusions, and educational implications will be discussed in depth.

1.4 Description of research

The purpose of this research is to investigate how students engage in a particular context throughout a course. These goals are addressed in Chapter 2 of the thesis, and is titled *Student Engagement: Exploring How and Why Students Engage In and Out of class*. Seven students were interviewed bi-weekly to recollect their engagement both inside and outside of the classroom. Interview data was then compiled and interpreted by the researcher to construct a case study for each participant. Students in the study reported a wide range of engagements and interactions with their instructional team, classmates, friends, and other professionals, which shared both similarities and differences from those of other students. Results from this study also suggest that student engagement is influenced by a series of contextual factors and individual characteristics such as course expectations, individual interests, and a willingness to collaborate. The potential value of these findings to educators and the research community are summarized within the final sections of this chapter.

1.5 Terminology

Within this thesis there are multiple terms which are used frequently and may differ slightly from that of the research community. It is important to consider the definitions presented here, so that consistency can be maintained throughout the document.

Student engagement:

Student engagement is a frequently used term used to describe the actions or behavior, cognitive or mental effort, and the feelings or emotions associated with academic-related work [7]. This thesis uses student engagement as the term used to describe any social interaction with others exhibiting behavioral, cognitive, or emotional correspondence a student has to academic work in a course.

Contextual factors:

Context is defined as the set of conditions that establish the background information pertaining to an event or experience. With regards to student engagement, contextual factors are those which shape the environment, or structure of the event which end up influencing the way that a student engages in a course [8].

Individual characteristics:

Individual characteristics refer to the personal influences that are related to student learning and engagement within this research. Vermunt [8] discusses a similarly named term, personal factors, as the influence of a student's learning process, their personality, age, and gender on their engagement towards learning.

Chapter 2 – Student Engagement: Exploring How and Why Students Engage In and Out of class

Jason J. Pascoe, Shane A. Brown and Nicole P. Pitterson

International Journal of Engineering Education (IJEE)
(Manuscript will be submitted)

2.1 Abstract

The foundation of student learning and the transfer of knowledge is stimulated through student engagement. Much of the student engagement literature to date has uncovered a wealth of knowledge regarding the ways in which students behave and how to maximize student retention. However, inadequate research has been conducted outside of the classroom, which has been deemed as important, if not more so, than in class student engagement. A framework presented by Fredricks, Blumenfeld, and Paris [7] describes student engagement as a multifaceted construct involving student behavioral, cognitive, and emotional engagements. Using this framework, the researcher explored student engagement in and out of a course, using semi-structured interviews, to identify contextual factors influencing how and why students engage. The objective of this study is to determine how and why students engage in and out of a course, and the contextual factors influencing said engagements. A series of weekly interviews with seven students in civil engineering and computer science fields were conducted across six courses. Interview recordings were transcribed and summarized into case studies based on descriptive and interpretive research methods. The result of this study suggests that student engagement is influenced by individual characteristics and contextual factors linked to the course. Individual characteristics include student interest, motivation, confidence, willingness to collaborate, and work ethic. Contextual factors include the course and assignment difficulty, expectations, structure, class size, social norms, group interactions between students, and the social network of an individual. The comparison of student engagement with respect to these influential factors yielded similar and unique experiences across in- and out-of-class environments. However, future exploration and research is needed to determine the extent of each influential factor on student engagement.

Keywords: student engagement; social engagement; case study; higher education

2.2 Introduction

The role of engagement in education has been acknowledged by educators for some time. For the last twenty years educational researchers have theorized that engaging students in the process of

learning can have significant benefits [9]. Studies on retention and persistence [4], conceptual learning [10], knowledge transfer and application [11] all point to the importance of classroom engagement. One common posit is that the connection between students and their instructors, classmates, and peers is established through engagement, allowing learning to occur. However, engagement is a dynamic concept that encompasses the interaction of observable and unobservable processes. For example, while students can be instructed to participate in classroom activities which can then be used as measures of their engagement, contextual factors interpreted by each individual student can also play a role in how or why they engage when engagement is not required. Based on their decision to engage with their peers students begin to form social networks with others. Interactions and participation with those in similar academic or extracurricular environments can further stimulate the development of relationships.

In an attempt to capture how students engage with a course, educational researchers have studied the behaviors and interactions of students with instructors, teaching assistants, and peers in both the classroom and out of classroom environments. Observational methods are commonly used by researchers collecting student engagement data for groups of students within classroom environments. Continuous use of this method inside the classroom has led to a broader understanding of student engagement types and their role within academic retention and success [12]–[14]. Despite there being substantial research observing student engagements in a classroom, minimal research has been collected outside of the classroom or between the two environments simultaneously. Many of the studies investigate student engagement outside of the classroom through surveys distributed to masses of students following to a defined set of questions. For example, the National Survey of Student Engagement (NSEE) collected information from nearly 25,000 first-year college students on their engagement in and outside of a course [15]. While these surveys provide the current trends in student engagement across the United States, they lack evidence regarding the influences of context and individual characteristics on student engagement inside and outside of a course that one could achieve through direct observation or interview methods.

Awareness of individual characteristics and contextual factors are necessary for determining how a student's engagement is influenced within a course. Individual characteristics are traits or factors specific to the individual. Examples of individual characteristics include pre-existing knowledge, the motivation to learn, and the influence of knowledge transfer as they relate to student learning [10], [11], [16], [17]. Recognition of individual characteristics provide evidence of how and why a student chose to engage when confronted with a specific task, assignment, or topic in a course. Contextual factors differ from individual characteristics because they are course and interaction centric. Access and presentation of course material [18], social rules of engagement (social norms) [19], and the presence or development of an individual's social network [19]–[21] are examples of contextual factors that may be present in a student's course. Contextual factors are just as important as individual characteristics, and elaborate on the course structure of assignments and interactions with materials and interactions between people. Together with the observation or perception of student engagement, individual characteristics and contextual factors can be used to understand not only how and why they engaged, but what influences contributed to specific student engagements in a course.

The need for rich and detailed descriptions of student engagement inside and outside of the classroom with respect to contextual factors and individual characteristics spurred the development of this research. The purpose of this study is to investigate the ways in which civil engineering and computer science students engage throughout a course, in the presence of individual characteristics and contextual factors. The results from this study will formatted into case studies, which summarize student engagements for each participant based on a series of interviews conducted. The researcher posit that these seven detailed accounts of student engagement in a course will contribute to the research of broader community on student engagement, and benefit stakeholders in the civil engineering and computer science fields at large.

2.3 Background

Educational researchers have studied student engagement to many lengths, including the impact of a student's interaction in extracurricular activities in relation to academic retention and success [2], [3]. In this study, the researcher attempts to make deep interpretive meaning from the detailed recollection of student participants and their engagements taking place in a course specifically. Bridging the connection between student engagement inside classroom environments, such as lecture, recitation, and laboratory sessions, in addition to out of class learning environments is crucial for understanding how students engage, and the unique structuring of individual characteristics and contextual factors that appear in each of these environments. For example, a student may interact with nearby classmates during an in-class activity or discussion, while out of class that same student may rely on their interactions with the instructional team, or a friend currently or previously enrolled in the course to aid them with course assignments and their conceptual understanding. Students utilizing course material, with respect to the course and assignment expectations and their interest, may influence how they engage. Additionally, each student interacting in the same discussion or activity may engage in their own unique way. The differences in student engagement represent the influences of individual characteristics and contextual factors.

Collectively, research studying student engagement has discussed the impact of social interaction on student learning and retention. The 2016 National Survey of Student Engagement (NSSE) recently published a list of high-impact practices, all of which are social interaction centric about academic learning [15]. Among these practices are learning communities, academic-related research with faculty, and culminating senior experience, which give students opportunities to learn through interaction with others. Additionally, Michelene Chi [12] concluded that learning through social interaction generated the greatest retention rate of student learning when compared to constructive, active, and passive engagements. The role of social engagement can arguably be seen as an important component of student engagement.

Fredricks, Blumenfeld and Paris [7] suggest that student engagement can be broken down into three core components: behavioral, cognitive, and emotional engagements. These three types of

engagement are seen as features to characterize engagement holistically, and are adaptive to changes in environment and context. Furthermore, these types of engagement can be seen in as components relating to social engagement, as depicted in Figure 2.1 below. Social engagement has been shown to have considerable impact on in class [22] and out of class learning [23], which stresses the importance of capturing social engagement information in and out of class. Due to the uniqueness of each student and learning environment, social interactions become influenced by individual characteristics and contextual factors. These influences alter the perception of the student performing the engagement. When recalling social engagements, components of the student's behaviors, thoughts, and feelings can be related to Fredricks et al. [7] framework of student engagement. The process in its entirety will be discussed in depth in the following sections.

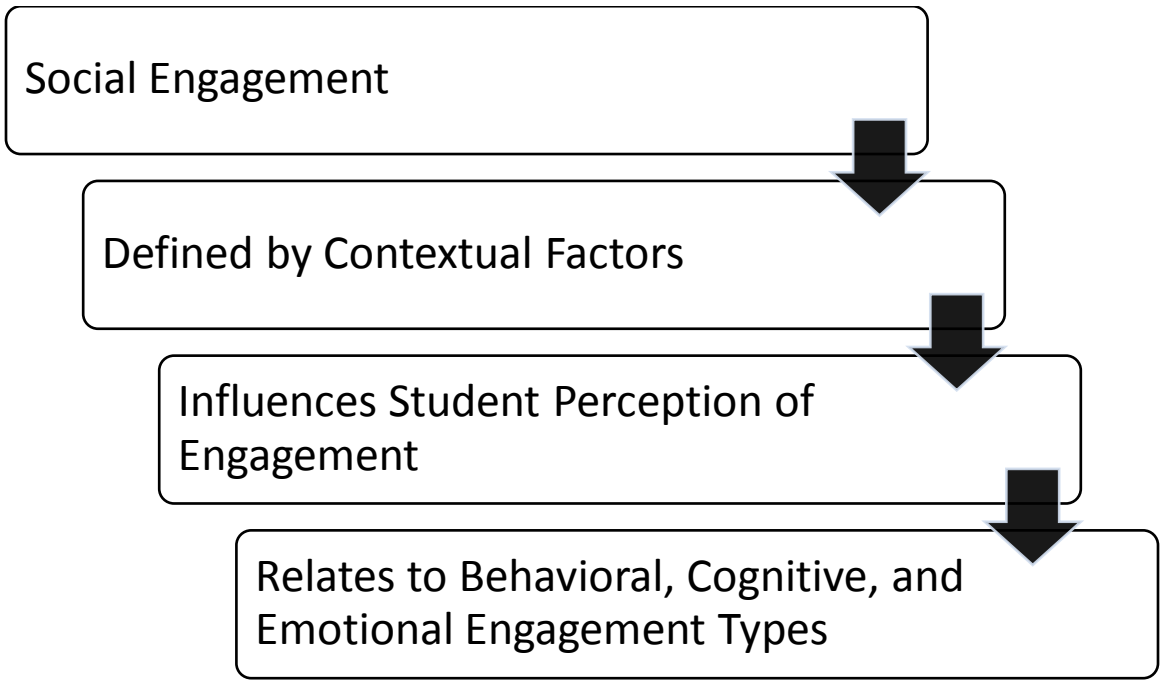

Figure 2.1: Social engagement relation to Fredricks, Blumenfeld, and Paris [7] framework of student engagement in a course

2.3.1 Social engagement

Research regarding student engagement has suggested that social interactions play a crucial role in student learning in and out of class. While exploring in class student engagement, Chi [12] determined that interactive engagement between peers yielded a deeper connection to the concepts and skills taught than engagements performed individually. Menekse, Stump, Krause, and Chi [13] built upon Chi's [12] previous work by studying interactive, constructive, active, and passive engagement types on student retention, and concluded that interactive student engagement led to a greater retention of course material. Both studies looked specifically at the overt behaviors of students during in class sessions. Conversely, Chen, Lattuca, and Hamilton [23] studied student engagement with an online course by developing an online interface where the course instructor could interact with students in real-time while they were notetaking. The study concluded that the student-instructor interactivity was seen as a benefit to students, even in an online environment. These studies, among others, not only promote the significance of social interaction within student engagement, but the need for understanding social engagement outside of an instructor-led learning environment.

Social engagement may involve the development or utilization of an individual's social network. Lin [20] suggests that there are intrinsic and extrinsic values associated with social interactions that take place within an individual's social network. For example, a student discussing a course assignment with another student may benefit by attaining answers to questions or develop a deeper understanding of concepts, which relate to intrinsic and extrinsic values. Additionally, Lin, Cook, and Burt [21] discuss how individuals with a larger social network have more resources embedded within that network, which has a perceived value. The authors specify four components contributing to value, which include the information, influence, social credentials, and reinforcement between the individual and another person within their social network.

Students themselves may influence the outcomes of social engagement in a course. For example, Bransford, Brown, and Cocking [11] discuss how pre-existing knowledge and the motivation to learn relates to student learning. The act of learning requires students to build or construct information based on pre-existing knowledge, which has been shown to influence how students

reason, assemble, construct, and organize new information [10], [11], [17], [8]. Dweck [16] found that student motivation towards learning is based on their “orientation”. If a student is “performance oriented”, they will tend to be focused on attaining a specific goal rather than understanding the concepts or skills. “Learning oriented” students will focus on the opposite. Motivations can also fluctuate based on the complexity of a goal, as individuals can become frustrated or inspired, affecting the outcome of their goals. Entwistle, Mccune, and Walker [24] summarize these orientations in terms of intrinsic and extrinsic motivation. Vermunt [8] describes how different “personal factors”, including a student’s learning process, personality, age, and gender influence their learning. The learning process was classified into two types: undirected and reproduction-directed learning. Between these two types of learning processes, personality, age and gender were seen as influencing variables.

2.3.2 The role of context

Social engagement has also been shown to be dependent upon a variety of contextual factors. Bransford, Brown, and Cocking [11] suggest that the access to knowledge and the influence of knowledge transfer relates to context. Furthermore, Bransford et al. summarize Simons [18] work on access to knowledge by discussing how the presentation of course material influences student engagement. For instance, science textbooks spend time explicitly deriving equations and laws, leaving students to interpret when these laws would be best used. The resources students use to learn have an impact on how they develop knowledge. Knowledge transfer is a term used to describe an individual’s ability to utilize knowledge between multiple contexts or situations [25]. Students are regularly asked to transfer their knowledge from the context of a lecture given in class to that of a test. This transfer of knowledge between one context and the next could influence the interactions students have with other students, peers, or their instructors.

Context also differs based on the learning environment. Vermunt [8] explains that the environment is responsible for variability in the way that students learn. The classroom environment is structured in a way to facilitate learning through the interaction between students and the instructor, course material and handouts presented in class, and other students. This

environment changes outside of the classroom, where the presentation of materials and information is not structured similarly, and interactions are influenced by the environment itself. For example, the interaction between two students preparing for a final examination in a library are different than a student who job shadows a professional engineer conducting field studies. The differences in environmental interaction between these two examples illustrates the potential influence on student learning.

To summarize, the factors described above provide evidence that learning is influenced by the learning environment, individual, and the social engagement a student may have with their instructors, classmates, and peers.

2.3.3 Fredricks, Blumenfeld, and Paris [7] framework of student engagement

Fredricks et al. [7] use behavioral, cognitive, and emotional engagements to describe student engagement holistically. They state that these three types of engagement work together dynamically, and are used to better understand student engagement altogether. Furthermore, Fredricks et al. [7] framework on student engagement can be related to social engagement to provide deeper understanding of student engagement holistically. Table 2.1 outlines these relations, and the following sections will describe these points in detail.

Table 2.1: Relation of social engagement to the definitions of behavioral, cognitive, and emotional engagements as discussed by Fredricks, Blumenfeld, and Paris [7]

Engagement Type	**Literature supporting Fredricks, Blumenfeld, and Paris** [7] **framework of student engagement**	**Relation to social engagement**
Behavioral	• "Involvement in learning and academic tasks and includes behaviors such as effort, persistence, concentration, attention, asking questions, and contributing to class discussion" [2], [26], [27].	• Cooperative participation in academic tasks facilitate social interactions that influence the outcome of a student's behavior. These behaviors may be similar or different from

	• "Positive conduct, such as following the rules and adhering to classroom norms, as well as the absence of disruptive behaviors such as skipping school and getting in trouble" [2], [3].	how they would have behaved without social interaction. • Student behavior while interacting with the instructional team, classmates, or other peers may differ between in and out of class academic environments.
Cognitive	• "Academic work as the 'student's psychological investment in and effort directed toward learning, understanding, mastering the knowledge, skills or crafts that the academic work is intended to promote'" [28].	• Social interaction provides additional opportunities for students to construct new knowledge through cognitive thought and reasoning. • Prior engagements in a course resulting in confusion, misunderstanding of concepts, or expectations may prompt social interaction with those more experienced with the concept, task, or assignment.
Emotional	• "Students' affective reactions in the classroom, including interest, boredom, happiness, sadness, and anxiety" [27], [29]. • "Identification as belonging (a feeling of being important to the school) and value (an appreciation of success in school-related outcomes)" [3].	• Social interaction regarding academic tasks may elicit a variety of student emotions (joy, frustration, confusion, excitement). • Emotion towards a course or assignment may also motivate students to initiate social interactions with the instructional team, classmates, or other peers outside of the course.

2.3.3.1 Behavioral engagement

Behavioral engagement in education relates to any action a person takes with regard to academic learning. Examples of behavioral engagement include student persistence, attention, effort, and contributing to class discussion or in class activities [2], [26], [27]. Behavioral engagement can also take the form of individual or collaborative efforts associated with academic tasks. Research

conducted by Michelene Chi [12] observed student behaviors through overt observation in class. From her study, learning activities were categorized as interactive, constructive, active and passive. Interestingly, Chi [12] discovered that interactive behaviors between students and the instructional team or with other students led to an increased retention of knowledge when tested academically. Menekse et al. [13] followed Chi's [12] research, which continued the observation of overt behavior of students in class to reinforce or deny her previous findings. Consequently, their research presented the same results, with interactive student behaviors leading to increased test scores.

Behavioral engagement relates to social engagement in multiple ways. As mentioned previously, student interaction with their instructional teams and classmates have been proven to be an effective way for students to learn and retain knowledge in the classroom [12], [13]. Additionally, student behaviors while interacting with others are reflective of the social norms in a particular environment [2], [3]. By studying social engagement in depth, the influence of social norms on behavior may also be discovered. Many of the studies to date have observed the behaviors of students within classroom environments, creating an imbalance when little is known about out of class behaviors and interactions. Student social engagements outside of the classroom are not constrained by the same social norms as a classroom environment, allowing students to interact in unique ways.

2.3.3.2 Cognitive engagement

Cognitive engagement is defined as the psychological investment that a student exerts towards learning, understanding, and mastery of the concepts, skills, and crafts taught through academia [28]. Fredricks, Blumenfeld, and Paris [7] posit cognitive engagement can be placed in two different levels: surface level and deep level. Surface level cognitive engagements are those that avoid cognitive effort or relies on getting help. An example of surface level cognitive engagement is asking questions about an assignment or concept. Alternatively, deep level cognitive engagement includes showing high levels of attention and persistence to comprehend, construct, synthesize, and relate new information into the existing knowledge.

Cognitive engagement is tied to social engagement as learning is a social process. For instance, students discussing a homework assignment may also be cognitively engaged on a deep or surface level. What might start out as simply sharing work or thoughts might evolve into further discussion or clarification of a particular problem or concept within the assignment itself. A surface level cognitive engagement could develop into a deep level with the influence of social interaction. Deep level cognitive engagements can also become surface level if students were deeply engaged on their own, but sought help from the instructional team to address a specific problem or concept quickly. Cognitive engagement changes dynamically with behavioral and emotional engagements [7], so it is important that all types of engagement be considered when relating to social engagement.

2.3.3.3 Emotional engagement

Two definitions of emotional engagement are discussed by Fredricks, Blumenfeld, and Paris [7]. Firstly, emotional engagement can be defined by the feelings or reactions to a course. Consequently, emotions like happiness, boredom, sadness, excitement, and others can be felt when emotionally engaging with course material [27], [29]. The second definition breaks down emotional engagement into four pieces of value: “interest (enjoyment of the activity), attainment value (importance of doing well on the task for confirming aspects of one’s self-schema), utility or importance (importance of the task for future goals), and cost (negative aspects of engaging in the task)” [30]. By integrating both definitions, emotional engagement can provide information not only how students feel during a particular engagement, but what it means to them emotionally to be engaging in that way. While the literature is not explicit with any result as to the effect of positive emotion on investment or retention of academic knowledge, emotional engagement does influence the way in which an individual chooses to engage with course material and learning. For instance, a student who is tired and bored in class may not take notes or pay attention to the lecture, while a student who is interested and happy may be asking questions, or attentively following along with the lecture. Emotions may change over time, and

reinforce the need for emotional engagement as a component of defining student engagement holistically.

The ways in which emotional engagement relate to social engagement stems from the student's feelings, interests, and perception of values. A student who struggles while studying alone may feel sad, confused, or annoyed, and become motivated to interact with someone who is knowledgeable and willing to help them. These feelings can also change during or after social interaction, which influences the outcome of that interaction and future interactions with that person or group. Values tied to attainment and utility are types of emotional engagement that are specific to the individual, and have the ability to influence how a student behaves, thinks, and interacts with others [30]. A student who learns about a concept that is used frequently within their discipline could be inspired to engage in further discussion with the instructional team or professionals within the discipline to develop a mastery of concepts or skills. The emotions elicited by social interactions provide greater understanding of their emotional engagement in the course.

This research posits that social engagement be described by the interdependency of contextual factors, individual characteristics, and behavioral, cognitive, and emotional engagements. The literature describes how a student's behavioral, cognitive, and emotional engagement are interwoven to holistically understand their engagement in a course [7]. Additionally, individual characteristics and contextual factors provide insight to the environmental and personal influences on student engagement [11], [8], [24]. These five components form an interdependent relationship which will be used to interpret student engagement. Figure 2.2 presents the relationship between these components.

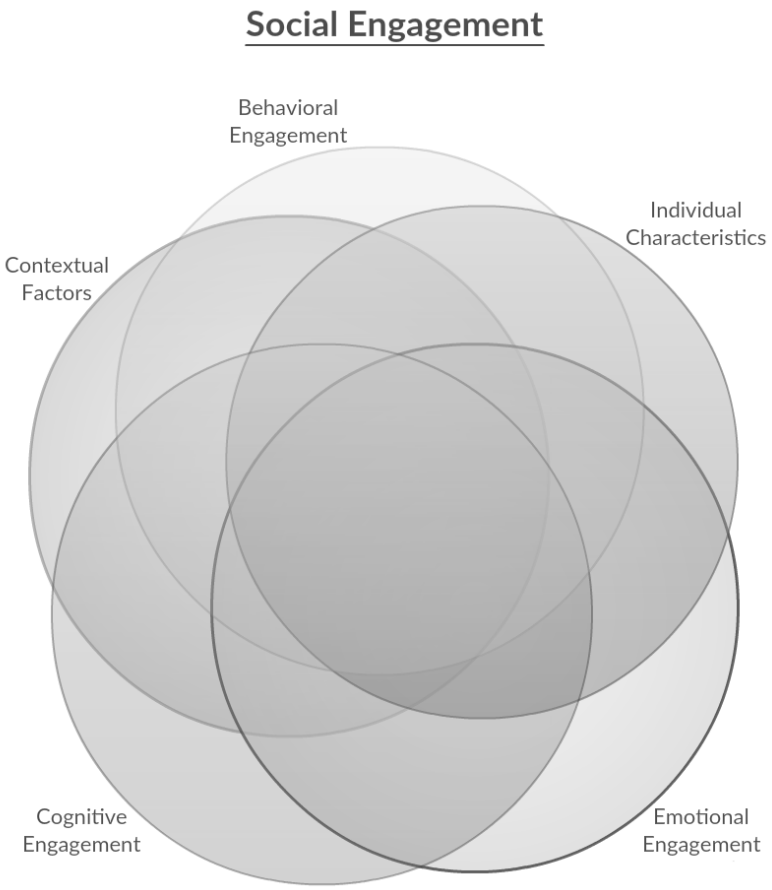

Figure 2.2: Interdependent components of social engagement

2.3.4 Research objective

The role of social interaction within student engagement in a course has been proven to be valuable asset towards reaching academic success. However, previous research studies student engagement in or out of the classroom exclusively, creating the need for student engagement and social interaction to be investigated holistically across all learning environments.

Utilization of Fredricks et al. [7] student engagement framework alongside existing literature reporting the influences of contextual factors and individual characteristics will be used to interpret social engagement in a course. It is believed that social engagement embodies the foundation of Fredricks et al. [7], while providing insight to the contextual factors and individual

characteristics influencing student-peer interaction. Thus, further use of student engagement in this study refers to the social interactions of students both inside and outside of a course. By operationalizing social engagement with respect to Fredricks et al. [7] framework of student engagement in a course, this study will explore the following questions to describe student engagement holistically:

1. How do students engage in a course?
2. How does social engagement relate to individual characteristics, and behavioral, cognitive, and emotional engagements within a particular context?

2.4 Methodology

2.4.1 Study design

This exploratory study aligns with Fredricks et al. [7] description of student engagement, which acknowledges student engagement as a dynamic process involving behavioral, cognitive, and emotional engagements. This study specifically focused on participant social engagement as it best represented the constructs of behavioral, cognitive, and emotional engagements, outlined by Fredricks et al. [7], in addition to contextual factors and individual characteristics. The intent of this study is to explore how students engage through social interactions with the instructional team, classmates, and other peers to determine factors influencing these engagements both inside and outside of a course. To achieve this goal, a qualitative case study design was employed so that rich, detailed information could be collected and analyzed per each participant [31], [32]. Case study data was collected through semi-structured interviews with students, who were asked to self-report their engagements in and out of class. Participants were interviewed on a weekly or bi-weekly basis, where each interview built off of the previous one. Altogether, these recollections provide a holistic account of their engagement in a course.

2.4.2 Participant selection

Students enrolled in a civil engineering or computer science course at a large research intensive institution in the Pacific Northwest were invited to participate in this study. In total, seven

students were selected through convenience sampling and their availability throughout a ten-week term. The cohort of students attended the same institution as the graduate researcher, and had previous interaction with them prior to the study. From those selected, five (5) graduate and two (2) undergraduate courses were identified across various engineering and technology courses. Participants individually met with the graduate researcher prior to the first interview to inform them of the research intent and to collect their contact information for scheduling future interviews.

2.4.3 Semi-structured interviews

Qualitative data was collected through semi-structured interviews with the participants. An interview protocol was developed to guide participant recollection of their engagements in and out of class. The questions were designed to target specific settings, such as lecture, recitation, or laboratory sessions, in addition to any other out of class settings. Once a question was posed, participants would begin recollecting their engagements in a particular setting, but were not forced to remain there. For instance, if a participant were originally discussing an engagement taking place in a laboratory session, but continued to engage out of class on the same assignment, the participant would be encouraged to continue. Follow-up questions were created to clarify any previously mentioned interaction or to spark further conversation regarding the current topic of conversation. Table 2.2 provides an example of a semi-structured and follow-up question used during the interview process. No time restrictions were placed on the interviews so as to allow participants as much time as they needed to cover as many engagements as they could recall. Interviews spanned a range of 15 to 75 minutes in length. The researcher took written notes of each interview, coupled with audio recording to document participant engagements.

Table 2.2: Examples of interview questions asked

Code Group	Interview Questions
Social	Who were you working with? How did you work with them to complete the [laboratory/homework] assignment?

Context	Tell me about how you used the laboratory equipment to work with your group.
Behavioral	How did you complete the in class activity that day? Was there any discussion afterwards?
Cognitive	What did you learn from your interaction with [person/group]?
Emotional	How did you feel after completing that assignment?
In class	Tell me about your interaction with [person/group] in class.
Out of class	Did you end up talking about [course] with any of your peers outside of class?

2.4.4 Data analysis

The transcriptions were checked for grammatical and content errors before being uploaded to Dedoose [33], a web-based application which provides storage, management, and analysis for qualitative and mixed-method research [31], [32]. The researcher developed a qualitative coding system which categorized behavioral, cognitive, and emotional engagements by aligning with Fredricks et al. [7] and social engagement inspired by Lin's [20] definition within a specific setting. Table 2.3 includes the engagement type, the code, and a description of the engagements placed within those codes.

Table 2.3: Examples of codes used in Dedoose software

Topic	Code	Description of sub code
Social Engagement	Resource(s)	Any time an intrinsic or extrinsic object or action of value to the participant was discussed during an interaction
	Social Network	Used when a participant interacted with or developed a meaningful relationship within another person.
Setting	In class	Student engagement taking place within the lecture, recitation or laboratory sessions.
	Out of class	Student engagement taking place anywhere besides the lecture, recitation, or laboratory sessions.
Contextual Factor	Social Norms	Used when the participant described any factor influencing the rules of social interaction with regards to a specific environment

Individual Characteristic	Value	Participant description of interest, cost, attainment, utility or importance of an assignment or concept in a course.
Behavioral Engagement	Participation	Individual participation was coded when the participant engaged alone, and cooperative participation was coded when the participant described any collaborative engagements with the instructional team, classmate(s), or other peer(s).
Cognitive Engagement	Deep or Surface Level	Deep level cognitive engagements were coded when an engagement contributed towards the mastery of concepts or skills in a course. Surface level cognitive engagements were coded when participants asked or received help, and when minimal thought was used.
Emotional Engagement	Affective reaction	Any time a participant described their emotion towards an interaction or engagement with the instructional team, their classmates, other peers, or the class in general (i.e. joy, sadness, stress, or boredom).

As the researcher coded interview transcripts about student engagement inside and outside of a course, the codes that reflected the event were selected. For example, an excerpt from an interview with Kacie is provided in Figure 2.3 below.

Kacie: Then on Tuesday, Amanda showed me how to - luckily it was actually worked out. I hadn't inserted yet, I was going to do it by hand, the soil layer in my map, like showing where the different soils were located. Someone had showed her that we could just take it off the web soil survey and just take it right off and put it into AutoCAD and lay it over the drawing I already had since I've like put it in there. That was nice, so we did that together. Later in the day I went in there and labeled what each - because it just put in the lines, so then I put in which section was each soil and did a little notes section of where I got the information and everything.

Researcher: Did it end up working out really smoothly?

Kacie: Yeah, yeah. There was, because we had to scale it, and at first we put it over and I was like, "eh, when I was looking at it this soil level was definitely way closer to the bridge than we measured" and realized we didn't scale it right, so we did have to re-scale it. That was one hiccup, but other than that it went good. Luckily though, I stared at it long enough that I knew that it was wrong.

Researcher: And you put in the soil types on your own?

Kacie: Yeah, and then I went through and did all the detail on my own, but she showed me how to just put the layer right on top of what I already had, so it was really nice, took a lot less time.

Figure 2.3: Example excerpt selected from interviews with Kacie

The researcher chose to use the codes: individual and cooperative participation, surface level, affective reaction, resources, social network, and out of class to best represent the excerpt described above. Kacie discussed how she worked individually to make introductory and concluding revisions to their soil layer map, in addition to cooperative help from Amanda because she was more competent with the AutoCAD software. Kacie elicited an affective reaction towards this engagement because she expressed how it was nice that they received help with the assignment. The use of AutoCAD software and the transfer of knowledge between Amanda and Kacie act as resources which influenced the interaction and provided value to the final soil layer map. Amanda was within Kacie's social network as they worked together previously with one another, and were assigned to the same project group.

Once qualitative coding and analysis were performed for each of the seven participants, the findings were synthesized. Participant interviews provided such abundance of descriptive information on student social engagement that it would be infeasible to elaborate on every instance. As a result, case studies were constructed to summarize information regarding the

participant, the course enrolled, summarization of their social engagement, a specific recollection of social engagement, and researcher interpretation of that social engagement.

2.4.5 Research quality

When gathering qualitative data, it is paramount that validity and reliability be considered. Walther, Sochacka, and Kellam [34], [35] justified the quality of qualitative data collection and interpretation through theoretical, procedural, communicative, and pragmatic validation techniques coupled with the concept of process reliability. Their framework was constructed to define the validity and reliability standards of interpretive research, which differs from research utilizing direct observation and quantitative methods. Of the four aspects of validity, this study applied both theoretical and communicative validation techniques directly. Theoretical validation focuses on the connection between the social reality studied and the theories adopted by the research. This study explored student engagement holistically in a course through self-reported semi-structured interviews, which allowed for the emergence of the participant's social reality to be studied in depth. Additionally, communicative validity is defined by the connectedness of the data collected and the inter-subjective reality of the participant. This study addressed communicative validity by member checking and creating a shared narrative with the participant. The researcher conducted member checks by asking participants follow-up questions, which enabled them to either clarify or elaborate on an event. Shared narratives occurred during interviews with student engagements spanning multiple days or learning environments. The researcher conducting the interview would asked questions and provided summary of student engagements to give the participant time to add information and agree or disagree with what they had said. Walther et al. [34], [35] defined process reliability as the "extent to which the research process is independent from random influences". The use of an audio recording device and a third-party transcription service created a source of information that could be viewed independently of the researcher's perspective, and thus adding reliability to the study. Transcriptions were also reviewed after being received from the third-party service to justify alignment between the oral and written versions of the data.

Walther, et al. [34], [35] discuss the handling of qualitative data in a similar manner to the collection of data mentioned prior. Again, both theoretical and communicative validation techniques were used in the handling of data this study. Theoretical validation was achieved by iterating researcher interpretations multiple times for consistency. These iterations led the researcher to develop different perspectives, which were compared against other cases to understand the similarities and differences between participants. Communicative validity was achieved through peer debriefing and discussions between the researcher regarding the findings and conclusions from each participant to maintain consistency throughout all seven participants. Process reliability in handling data is explained by Walther et al. [34], [35] as the "proper definition and documentation of interpretation procedures". This study addresses process reliability by establishing a structured coding technique across all participant transcriptions, in addition to the methods employed to interpret transcription data.

2.5 Results

The participants in this study represented a six courses from the civil engineering and computer science fields that were offered on both graduate and undergraduate levels. Daniel and Kacie represented the undergraduate students in this study. Both are in their final year of study, and are almost completed with their required coursework. Daniel is pursuing a degree in computer science, and Kacie in engineering. Steven, Kim, Carter, Mitchell, and James recalled their engagements inside and outside of a graduate-level course. The graduate students were all enrolled in an engineering course. Table 2.4 lists the general information regarding each of the participant's course and their academic level.

Table 2.4: Participant summary

Name	**Course Focus**	**Academic Level**	**Term Enrolled**

Steven	Geographic Information Systems (GIS)	Graduate	Fall 2015
Daniel	Computer Science	Undergraduate	Fall 2015
Kim	Transportation Engineering	Graduate	Fall 2015
Carter	Transportation Engineering	Graduate	Fall 2015
Mitchell	Structural Engineering	Graduate	Fall 2015
James	Geotechnical Engineering	Graduate	Fall 2015
Kacie	Civil Engineering Design	Undergraduate	Winter and Spring 2016

Each case study begins with an introduction of the participant which describes their academic credentials and how the researcher knows them to be. Next, a synthesis of the participant's course structure and the assignments were described. This allows the reader to understand what the participant had to work on throughout the course. A summary of the participant's social engagements with the assignments inside and outside of class are presented in the section afterwards. Summary of the participant's social engagements provide understanding of how the student chose to interact with their classmates, instructors, and peers. Finally, the description and interpretation of a single event with regards to the participant's social engagement in the course are presented. Events were chosen by the researcher to bring forth examples of unique or typical interactions between participant's and their classmates, instructors, or peers, which were then interpreted by the researcher with respect to their social engagement throughout the course.

2.5.1 Case study: Steven

Steven is a second-year graduate student pursuing his civil engineering doctorate degree, and completed his undergraduate studies at another university. Steven is dedicated to his work in

school, and takes pride in his accomplishments. You can always find him working on an assignment for a course, or a report for work. He has written and presented literature to multiple conferences, and aspires to work in academia after completing his doctorate degree. Steven is an independent learner, and is willing to take the time to deepen his understanding of a skill or concept. In his office you can find him watching video tutorials, reading engineering articles, and running test simulations to troubleshoot any problems he might have ran into. Furthermore, Steven is also outgoing and very friendly with his colleagues and peers. He is involved with student organizations on campus, and is always an outlet when you need help.

2.5.1.1 About Steven's GIS course

Steven participated in a ten-week graduate-level geographic information systems (GIS) course. The course was comprised of two 50- minute lecture sessions and a single one-hour and 50-minute laboratory session. Lecture sessions primarily centered on the course instructor presenting the theory behind, and uses of, GIS. Halfway through the term, the course instructor invited professionals, researchers, and academic personnel to share how they use GIS in their line of work. During laboratory sessions, students were given an assignment and asked to manipulate various files and data in ArcGIS software, and were required to submit the deliverables of said assignment prior to the following laboratory session.

Nine laboratory assignments were issued to students, as the focus of the course was to learn and utilize GIS software in multiple ways. In addition to laboratory assignments, students received four quizzes, across all lecture sessions, and were required to submit a final project by the end of the term. Quizzes were given in class, and contained questions that were based on the material covered in the lecture notes. The final project required students to integrate many of the concepts and functions previously used in the earlier laboratory assignments into data related to a topic of their choice. The final project was described to be "as difficult as two laboratory assignments" by Steven's course instructor.

2.5.1.2 Steven's social engagement in and out of class

Throughout his GIS course, Steven recalled a variety of social engagements with the instructional team and his peers. During lecture, he explained that little to no social interaction took place, as the instructor typically filled the time by presenting GIS theory and inviting guest speakers to discuss their use of GIS in their respective fields. While students were encouraged to ask questions, Steven refrained because he felt that he could answer them at a later time. "Because I feel like I'm really new. I'm not just afraid to ask one thing, I'll think, oh I'll figure it out later". On occasion, he would wait until the end of lecture to ask the instructor his questions, but he primarily interacted with the teaching assistants (TAs) and his peers in the laboratory sessions.

Steven found himself asking for help in the laboratory sessions more than in lecture. This is mainly attributed to the fact that Steven was new to the GIS software that they were asked to utilize to create deliverables for each laboratory assignment. Steven wanted to learn as much about the ArcGIS software as possible, and felt that he could reach a deeper understanding of it by working alone at first. After Steven had ample time to interact with the software individually, he asked for help from the course TAs and his classmates nearby. When he eventually became stuck or confused, he would catch the TAs attention and Steven would share his work visually while presenting his question(s). There were two TAs in the laboratory sessions, each with their own style of helping students. "One TA will help you, he's like, 'Oh, what's wrong? I can help you do that.' Another one is like, 'Why don't you try to figure it out yourself.' Or he's like giving you a hint and just go". He preferred to interact with the first TA described, as their discussions would help Steven deepen his understanding with the GIS software. Steven's choice to interact with the TAs over the course instructor and the other students was based on his comfort with them. He states "I do have some conversations with the TA. Because I think they are [easier to talk to]...". Steven also communicated with the TAs during his work with the final project. Many of his questions were sent to the TAs via email, as he worked from his office. Social engagement with the TAs persisted all throughout the term. This was discussed in all of the interviews.

Social engagement with other students in class began after the first few weeks of the course. When the TAs were unavailable to help him during laboratory sessions, Steven would also reach out to the students sitting nearby. During these interactions, Steven was able to get his questions answered and continue working on the laboratory assignment. However, he preferred to interact with the TAs because he believed they knew the most information about the GIS software, and that he did not know anyone enrolled in the course. As the term progressed, Steven was assigned to a group of three to gather GPS data, which would be used to create the deliverables needed to complete their laboratory assignment for the week. The group socially engaged by discussing the lab procedure as they were collecting data. Steven's engagement with this group will be discussed in more detail in the following sections.

To prepare for the in class quizzes, Steven would interact with one other student in the class both in person and over email communication. Steven knew this student because they lived near one another, and this made it easy for them to meet at one of their homes. They prepared together by asking each another questions related to the topics covered in lecture. Steven reported that for two of the four quizzes he studied alone, it could be attributed to busy schedules, the lack of in depth studying needed, and Steven's personal choice to study alone.

2.5.1.3 Specific instance of Steven's engagement

The instructor placed Steven into a group of three students so that they could collect the data for a laboratory assignment. The requirements of the assignment were that students compared the satellite coordinates of various concrete markers provided to them, with global positioning system (GPS) coordinates that their group had to collect in the field. After being given a GPS device, Steven and his group began searching for the markers based on the coordinates provided. "When we got the point where the GPS notified us, 'You have arrived.' But, it is no concrete mark so we kind of looking around and see where is the concrete mark". They spent some time looking for the concrete marker and found it lying 35 feet away. At this point, Steven and his group talked about how the GPS device was not very intuitive or as accurate as they previously thought. "The GPS kind of tricky. We talk like, 'Where exactly is this?' We kind of talked.

There is a lot of communication between when we were figuring out how to use the GPS". Between each of the markers, Steven and his group passed off the GPS device so that by the last marker they would have all had a chance to operate it. Once they located each of the concrete markers, the group headed back to the laboratory to upload the GPS coordinates to a computer for comparison.

Shortly after starting the upload of coordinates, their group ran into software problems. One of Steven's team members had already began trying to troubleshoot the problems, but did not feel confident in their results. They managed to get the help of the course teaching assistant after trying to discuss the possible solutions. "We try and ask help from the TA and he got kind step-by-step that show us, 'Click this, click that.' We find out that yeah, we did this already. 'Yeah, you found it, you just didn't notice that'". The final coordinates were then shared, and each of the group members began manipulating the data in ArcGIS software. The deliverables for the laboratory assignment were finalized individually.

2.5.1.4 Interpretation of Steven's engagement

Of all the laboratory assignments shared during the interviews, this was the only time that Steven had socially engaged with a group of people for any significant amount of time. It is important to add that this engagement was required by the course instructor, and that Steven knew none of his group members prior to this assignment. The structure of this event shaped Steven's social engagement by provoking collaboration between members out in the field while collecting the coordinates and other details of the surrounding area. Additionally, their ability to interact with the TA during the laboratory session is related to the course structure, because TAs were required to attend and lead each of the sessions. It is fair to conclude that if the laboratory assignment had not required students to work in groups, Steven's social engagement would have resulted differently. Throughout many of the laboratory assignments, both prior and subsequent to the one described here, Steven routinely kept to himself. He would follow the assignment procedures to make progress, only stopping when he became confused or received an error in the software. During these times Steven would commonly interact with the teaching assistants, who

would help him by offering hints or walking through the process together. Many of these interactions took three to five minutes, as the two TAs were responsible for helping all of the students in the laboratory. Forcing Steven to collaborate with other students provided the unique structure creating this one-of-a-kind social engagement between Steven and his group members.

Steven's social engagement with the group is also connected by his interest in the course and his willingness to collaborate with his peers. Steven's intentions for enrolling in the course were centered towards his interests in, and the potential value of GIS software in transportation engineering industry. "My point is it teach me some knowledge, background of GIS, but what really matters is how do you use GIS". Steven's interest in GIS encouraged him to collaborate with the other students during the laboratory assignment, as it would deepen his understanding of GPS technology and its role in GIS software. When Steven and his group were faced with a series of problems while using the GPS device, he added to the discussion of possible ways to solve the problems. For instance, "The first time, the girl she was holding the GPS and she accidentally paused the point and it says, 'You've been arrived,' but when we go back it didn't have any notifications". As a group they were able to figure out that the device had been set to "pause", and that they needed to reorient themselves. Steven's interest in the device and its software motivated him to contribute to group discussion, and this same interest fueled his engagements both in and out of class. He even expressed joy after completing the assignment when he stated, "We actually did a really interesting lab this week".

2.5.2 Case study: Daniel

Daniel is currently a fourth-year undergraduate student pursuing a degree in computer science. Daniel transferred to this university after completing many of his baccalaureate courses at another institution. This transfer was because the prior institution Daniel attended did not have a computer science bachelor's degree program available.

Daniel has adapted to his current university quite well since his transfer. He finds computer science interesting, which motivates him to complete his course assignments and master the

concepts and skills taught in the classroom. Daniel described himself as someone who prefers to work alone, because it allows him to focus on his work. However, Daniel's recollection of engagements in this computer science course shows that he is willing to work with others, and interact with the instructional team when aid is needed by either party. Having known Daniel personally for many years, his engagements within the computer science course are representative of his character. Daniel manages his time effectively, with occasional events where assignments may take longer or shorter than expected. There were times during this course where Daniel procrastinated his work, but was able to receive help from his peers or the instructional team to get the assignment completed. His recollections have provided deep understanding of the concepts taught throughout the course, and his engagements with the course assignments reflects this understanding.

2.5.2.1 About Daniel's computer science course

The computer science course Daniel was enrolled in consisted of in-class lecture, laboratory, and exercise sessions each week. Concepts were taught during the two 50-minute lecture sessions per week, a one-hour and 50-minute laboratory session per week gave students time to apply said concepts. Students also had the opportunity to attend a 50-minute exercise session each week to receive additional help from the instructional team.

The lecture sessions were headed by the course instructor, along with the occasional input from the teaching assistants. As described by Daniel, majority of the lecture sessions began with the course instructor presenting a PowerPoint presentation, followed by a classroom question and answer discussion period regarding any of the assignments or topics taught. Approximately 100 students regularly attended each lecture session. Lecture slides were readily available online for student access.

Assignments were given each week during the laboratory sessions. Two teaching assistants led these laboratory sessions of approximately twenty students, who were responsible for fielding student questions and approving their assignments before grading. Sessions were held in a small

computer laboratory, which gave each student access to a school computer if they chose to use them. Laboratory assignments that were not finished during the laboratory session would need to completed outside-of-class before the following session.

Exercise sessions were offered as an optional and alternative way for students to complete their assignments. “You have a choice of either meeting up as a group with a TA and going over the exercise or you can do it on your own and then turn it in”. Each exercise assignment asked students a variety of conceptual questions relating to the course lecture, laboratory, and homework topics. Their time in the exercise sessions were primarily spent collaborating as a group by discussing or answering the conceptual questions.

Outside the class students were assigned four homework assignments, two online quizzes, a journal documenting their code logic, and a final project, in addition to any laboratory or exercise assignment that was not completed in class. Homework assignments were due two weeks from the assigned date. The twenty question quizzes asked both multiple choice and true/false questions pertaining to the in class lecture sessions, and could also be retaken for a better score. Students were asked to recreate the card game “Go Fish” for their final project, with working artificial intelligence (AI) players that make choices based off previous turns. Daniel’s instructor described the project as “a slightly larger homework assignment”. The final project was used in place of a final exam.

2.5.2.2 Daniel’s social engagement in and out of class

In lecture, students were encouraged to ask questions during the in class discussion periods to help clarify computer science concepts or their course assignments. Daniel chose to remain silent, because he felt confident in his understanding of the course concepts. “I personally didn't ask any questions because I seem to grasp the concept pretty well. I generally just listen to the other students and the instructor's response, as well”. Daniel had completed the course the previous year, but decided to retake it for a better grade. Having seen the course a second time, this factor influenced the way Daniel social engaged in the lecture sessions.

Additionally, Daniel's lack of social network influenced his social engagement. Daniel did not recall knowing any students in the course, or the instructional team prior to his enrollment. Having no friends or acquaintances to interact with in the lecture sessions, Daniel chose to sit quietly and listen. When asked about his interactions in more depth, Daniel discussed how he preferred to work alone and called himself a "loner". However, his lack of a social network made him more open to interacting with new people in the laboratory and exercise sessions. For instance, Daniel collaborated with his neighbors in the optional exercise sessions by discussing the questions presented to them by the teaching assistant. The students were later asked to discuss altogether, and Daniel chose to share his thoughts with the class. This provided Daniel with an outlet to collaborate with his classmates to solve the exercise questions in class.

When Daniel began working on his first laboratory assignment, he quickly realized that the software was different than he had used the last time he was enrolled in the course. His neighbor saw him struggling and offered to help. Over time Daniel became acquainted with his neighbor, which he called his lab partner even though they were not assigned to work together, and they helped one another with the weekly laboratory assignment. Each week, Daniel would describe how they would collaborate by providing hints, ideas, and thoughts to one another to reduce the time needed to finish the assignment. The instructional team encouraged students to collaborate by discussing with others about the assignment, but required students to produce their own work. This reinforced Daniel's choice to interact with his lab partner on a weekly basis, but also ensured that he did not share his code.

Daniel frequently interacted with the teaching assistant in the laboratory session, as they were responsible for approving his work before submission. The teaching assistant also helped Daniel during points of confusion or misdirection. "He [the TA] looked at the errors and read through them with me. Then he looked at my code, and he explained why I was getting the error and what the error was trying to say". Daniel's engagement with the TA typically involved bringing his laptop to the front of the room to share his code to have it looked over. When Daniel had his

code done correctly, he was approved to submit the assignment, and if not the TA would explain where he needed to fix the code. As he interacted with the TA more, he became more comfortable asking questions and explaining his thoughts as the TA reviewed his code.

Outside of class Daniel shared a single instance of social engagement with his peers. Homework assignments and quizzes were completed on his own, as he felt confident in his ability to complete them on time without help from others. However, on two occasions Daniel was not able to complete an assignment before its deadline, resulting in a suboptimal grade. His choice to not collaborate with others was a result of his proclaimed procrastination, which could have been altered had he left enough time to collaborate with his peers and complete the coding process. Daniel was able to interact with a group of his classmates briefly regarding the final project. Because the group was further along than Daniel, he was able to get a few hints to save some time. While this helped, the project was so large that he was not able to complete it prior to the deadline. His choice to procrastinate with the various assignments and final project influenced his social engagements both positively and negatively. By waiting until it was too late, there was less of a chance that his peers would be available to provide help. However, this helped Daniel during the final project because the group of classmates might not have known the information they did if he had asked them earlier.

2.5.2.3 Specific instance of Daniel's engagement

The episode discussed took place during an in class laboratory session in the fifth week of the term. The laboratory assignment asked students to write a code that altered the contents of a file by a set number of values, which are specified by the user. Daniel explained how the function would operate with a user input of one, "so if you had ABCD was the line it was getting, it would change it to BCDE. It would add one value to each one [letter]". He began by reading through the code of the file provided to determine how could be integrated with the user input that he needed to prompt. After reading through the file code and the laboratory assignment, Daniel wrote the code for prompting the user for the value to alter each letter in the file. It took Daniel half of the laboratory session to understand the assignment and write the code for the user

inputs. At this point Daniel tested his code to make sure that it was working correctly. He noticed that there was a symbol in the output of his code, and asked the teaching assistant to make sure the symbol was not an error. The teaching assistant assured him that the symbol was normal, which put Daniel at ease that he was one step closer to being finished.

Around this time Daniel's lab partner came into the laboratory, and began asking Daniel questions about how to work through the assignment. Daniel sat down next to him, and talked through what he learned from reading the file code and his feedback from the teaching assistant. Specifically, Daniel stated that he, "helped him out with just some initial things like I told him what the code was doing in the first place because it was hard to figure out just from looking at it. I showed him what we were supposed to do. I didn't give him the code or anything, but I was like, 'Yeah, you're just supposed to change that so it'll take a character from the person'". As they both worked on the assignment, Daniel continued to provide hints by pointing errors on his lab partner's screen, and got him caught up to where Daniel currently was. Towards the end of the laboratory session, Daniel asked the teaching assistant for their help with an error he was having while trying to reference his values within the file provided to him. They were able to find out that Daniel's code did not have a function to reference the values, and stopped working on it at that point because it marked the end of the in class laboratory session. Daniel was able to complete the rest of the assignment outside of class before the next laboratory session.

2.5.2.4 Interpretation of Daniel's engagement

Daniel's social engagement in the other laboratory sessions were very similar to the one described above. He would routinely check in with his lab partner to see where they were at in the assignment, and either give or receive help as they asked questions to one another. In this instance, Daniel went out of his way to make sure his lab partner was understanding what needed to be done to complete the assignment. Having never met this person prior to the class, it was interesting to hear Daniel share how his social engagement with his lab partner changed over time. In prior weeks, Daniel would be behind or come into class late, and his lab partner would answer Daniel's questions to minimize his time spent being confused or questioning his line of

reasoning. Their interactions were short and frequent, where they would point at each other's screens, compared thoughts, and provided the feedback given by the TA to one another.

Referring to the instance described above, Daniel's engagement changed between when he was interacting with the TA or his lab partner and when he was working alone at the start of the laboratory session. Daniel began the assignment by reading through the files provided by the TA to get an idea on how he could manipulate it. "I actually started to make some changes, and I figured out where I needed to go. Then, I implemented the changed and did what I thought was correct". He thought he was correct, but it turns out that after conversing with the TA, he had missed an internal error within the file provided and went back to fix that. Had Daniel not checked in with the TA, they would not have been able to discuss the error that he found. He was able to then share his feedback from the TA with his lab partner, who had just sat down to get started. "I believe the rest of the lab was just me helping him out, and then me trying to figure out what I was supposed to do next". They both were unable to complete the assignment before the end the laboratory session, but Daniel explained that the assignment was more technical and not time consuming. He made no mention of his lab partner helping him make progress on the assignment, meaning that Daniel's decision to help his lab partner was a result of the reciprocity he had received during earlier laboratory assignments. Had Daniel worked alone during this assignment, there would have been the possibility that he could have finished it entirely. In the end, he felt happy to have the assignment completed and to have helped his lab partner, "It was a pretty cool lab though. By the end, I felt pretty smart".

2.5.3 Case study: Kim

Kim is a first year graduate student pursuing a civil engineering degree with a focus in transportation engineering. One of Kim's greatest strengths as a student is her work ethic, which is driven by her genuine interest in transportation engineering and drive to master the concepts and skills taught through her coursework. This work ethic extends beyond individual assignments, as her peers regularly describe Kim as a valuable team member both in her ability to work cohesively with the group and construct quality deliverables. Kim commonly expressed

that she keeps to herself during class, and typically prefers to work individually on assignments, but is not opposed to working with others when required or encouraged. In addition, her curiosity and drive for conceptual mastery has encouraged her to network with her peers to provide further clarity of learned topics and discuss work done on course assignments.

2.5.3.1 About Kim's transportation course

Kim described her engagements with a transportation engineering course, which focused on traffic operations and design. Students were required to attended two fifty-minute lecture sessions and a one-hour fifty minute laboratory session each week. Kim was one of 24 students enrolled in the course.

Lecture sessions were structured to include a variety of PowerPoint presentations, student handouts, in class activities, classroom discussions, and additional hand written notes via whiteboard to disseminate information. Students were frequently asked to interact with one another, and participate in class discussion, to provide an alternative to traditional lecturing via PowerPoint slides.

Laboratory sessions began with a short summary of the previous lecture presentations, as these frequently aligned with the weekly laboratory assignment. Afterwards, a laboratory assignment was distributed and students could begin forming groups and start working for the remainder of the session. When forming groups, the instructor asked students to work with others that they had not previously worked with before, so that each student had a chance to work with other students in the course. A written group report was due one week from the assigned date, and students frequently completed the assignments outside-of-class before the deadline.

Weekly laboratory assignments were assigned in the first half of the term and a final project for the second half of the term. The project required students, who were randomly assigned to a group, to synthesize the data collected from the previous laboratory assignments to analyze the impact of a newly constructed storefront, hotel, and restaurant on the existing roadway

infrastructure, formally known as a traffic impact study. The final deliverables for the project included a written report, and an oral presentation. In the latter half of the laboratory sessions, students were allocated time to work on their final projects, as there was no more data to collect for the laboratory assignments once the project began. A final and midterm examination was issued to students during the fifth and last week of the course.

2.5.3.2 Kim's social engagement in and out of class

Classroom discussions and activities were very common in the course, giving Kim multiple opportunities to socially engage with her peers. When asked about these engagements, she regularly responded by saying that she worked with those in proximity of her. "First you.. I guess choose your own people you want to work with, I just chose them because one was close to me, and the other guy, said 'come over here and work with us'". As the course progressed, Kim found herself interacting with these classmates more often, attributing to the comfort, reciprocity, and value that these interactions contributed to her overall learning. For example, after working with Evan on previous course assignments, she felt comfortable asking him to help her answer questions during lecture, and in preparation for the final examination. Many times she had the opportunity to reciprocate because Evan occasionally needed help understanding the lecture topics and laboratory assignments. These interactions led to her deepened understanding of course concepts, which helped attribute to a passing score on the final examination. Interactions with these peers were structured around instructor prompted questions, where students were asked to collaborate to suggest a possible solution and discuss it with the rest of the class later in the lecture session.

There were times during lecture sessions where Kim would socially engage with her neighbor, Evan, as the instructor presented lecture material. When Kim became confused the with lecture notes presented in class, she would lean over and ask Evan if he understood them, and would begin a quick conversation to clarify the information. "I remember I was confused and was asking Evan about the.. alerted signal, that you have to use 0.7 to 0.75 for your reaction-perception time…". Other times, Kim would assist Evan with note taking when he forgot to

bring his glasses into class. These interactions were short in length, but frequently occurred throughout the course. Kim chose to interact with Evan frequently because of their prior experience working together on homework assignments and projects outside of this course.

Social interactions during the laboratory sessions were contingent upon the laboratory assignment complexity and Kim's group interactions. Each week leading up to the final project, Kim collaborated with different students in the class to complete the laboratory assignments. These assignments varied from the observation and collection of traffic data using laboratory equipment to the construction of traffic simulations on the computer as a group. Because of the assignment and group diversity each week, Kim described group interactions involving data collection in the field taking more time, while assignments requiring minimal or no field work taking less time and effort. Laboratory sessions began with a brief introduction to the laboratory assignment given by the instructor. Afterwards, Kim and her group typically started their work by collecting the contact information of each group member, and coordinating a time and place to meet in the field to gather data. For some laboratory assignments, Kim was able leave the classroom early with her group, and other times she returned to her office to create Microsoft Excel and Word documents to get her group organized. When the final project was assigned on the sixth week of the course, Kim was placed into a group of four students by the instructor, and were given time in the laboratory sessions to work together. The group started by dividing the project tasks to individual group members based on their expertise and interest. Each week Kim facilitated their group meeting to make sure that everyone was making progress, which was logged via a written checklist of tasks. Kim and her group regularly spent time discussing what needed to be done, and how they were going to complete each task. Majority of the work done on this project was done outside of class.

Outside of class Kim socially engaged with the course instructor, her friend Evan, and her final project group regularly. Interactions with the course instructor played a large role in Kim's understanding of the concepts taught in class, and various course assignments. For example, there were several instances where Evan was not able to answer Kim's questions in class, so she

waited until the lecture session concluded, and then asked the instructor directly. They were able to provide instantaneous feedback that Kim needed to clarify what was said earlier in the lecture. Kim frequently communicated with the instructor via email to receive help with course assignments. “I got an email from the instructor saying that they was back. So I had to run upstairs… I was there basically for more for asking question about the warrant analysis homework, and at the same time since I was there already I also asked about the trip generation. And he basically explained to me how to do it…”. Kim felt comfortable communicating with the instructor regularly because she had previously completed a course taught by the same instructor and knew that they would be able to help her.

Kim interacted with Evan outside of class during the week leading up to the midterm and final examinations. They spent a few hours together at the campus library, looking over the lecture slides and the in class activities to determine which concepts and ideas that they still needed help understanding. Then, Kim and Evan took turns asking each other questions and providing feedback as needed. The same method of studying was done for both the midterm and final examinations, but Kim spent more time studying for the midterm exam alone prior to her social engagement with Evan.

During the final weeks of the term, Kim frequently interacted with her project group members to make sure that work was getting done. She typically worked on the project in her office, and invited her group members to come visit her when they needed help on a task. Kim described one of her interactions with a group member by saying, “The other group member, because she’s not really familiar with synchro, so I would have to help her like, ‘this is what you just have to do. You just have to fix this traffic volume right here’. I recently gave them my notes because I don’t think they have the data for the traffic volume that we collected”. Even though Kim was not an expert with this software, or the material taught in class, she was able to help her group members finish their parts of the project. Between collecting field data, answering software and conceptual questions, and leading weekly meetings with her group, Kim managed to complete the final project in a timely manner.

2.5.3.3 Specific instance of Kim's engagement

The final laboratory assignment required students to develop a signal timing plan based on the green, yellow, and red times from multiple intersections across the city. During the laboratory session Kim chose to work with two other students, Evan and Carter because they sat in proximity to her in the lecture sessions. She knew Evan for over two years and had worked with him on many projects prior to this one. Conversely, Kim had never interacted with Carter prior to this assignment. After forming their group, the group left class to begin the assignment. "We had a small discussion like Evan and Zac back in the office trying to see which part we're going to do". From this discussion, Carter chose to collect the signal timing data, Kim would be working on analyzing the data using a software called Synchro, and Evan would be helping write the final summary of results.

That afternoon Carter returned to their shared graduate office with the signal timing data, and Kim began placing the data in Synchro. Carter had never worked with Synchro before, which is why he opted to collect the data instead, but was fascinated by Kim's ability to use the software. He eventually mentioned that he wanted to learn how to use Synchro at some point, and Kim convinced Carter to watch and learn. "I basically showed him how I did the entire model for that lab. Then, after that, I was just basically giving him all the basics and from there, he got to learn how to use synchro and he took over from there". Once Carter took the lead role on the computer, Kim began telling Carter where he needed to place the traffic volumes, lane widths, and other traffic information. After placing all of the necessary data into Synchro, Kim and Carter decided to stop work for the day, as the Synchro software can quickly run their simulation and provide written results that they would use in their laboratory report.

2.5.3.4 Interpretation of Kim's engagement

This interaction in particular was chosen because it is a representation of how Kim typically interacted with her group members in this course. The most intriguing part about Kim's recollection of this engagement was her feelings afterwards. "That was the first time I worked

with another person, since I've never worked with Carter before so that was the first time. It was nice actually working with different people". Why this is intriguing is because in the first and last interview with Kim, she spoke about her preference to work alone over working with others. She knew that she could get more work done in the same amount of time then if she had worked with other people. However, this instance, and others throughout the course, made her feel accomplished for collaborating with others. Even though Kim did not know Carter up until that laboratory assignment, she was still willing to help teach him how to use the software because he was interested and she knew how to help him.

Structure of the laboratory assignment also played a role in Kim's social engagement. Many of the laboratory assignments in the course required entire four-person groups to simultaneously collect traffic data in the field. However, this assignment in particular only required groups to record the traffic signal timing (the length of the green, yellow, and red times respectively), which could be done by a single person. Had Kim and her group gone out together, the engagement would have resulted differently. This ultimately left time open for Kim to work on the Synchro simulation and analysis, which was ultimately modified into a teaching and learning experience. She mentioned, "I actually learned something from him", when referring to a moment within their interaction where Kim was confused about a volume setting within Synchro, and together they were able to determine the appropriate setting needed for their simulation.

The group interaction between Kim, Evan, and Carter allowed for them to work together almost effortlessly to finish the assignment in a single afternoon. After determining what each person was going to work on, they got straight to work. "I basically just shared everything on Google Drive and let them work on it and that was the first and last time I saw that report. Which is good. That was really nice, finishing it on the first day it was assigned too". Because Evan was in charge of the report, Kim did not need to interact with him to any extent. This was not always the case with Kim's other laboratory and project groups. New groups of people presented Kim with a new context in which to interact with these people. When compared to Kim's social

engagement during the third laboratory assignment, group interaction played a bigger role in assignment completion. Kim described her experience collecting traffic counts, “Unlike everyone else, we got the roundabout, so it was a lot harder for us to collect data, just doing it by yourself, so we ended up partnering, like doing two persons at a time. Where one person is pushing two sides of the JAMAR board and the other one is more responsible for the other two.” By partnering up, Kim and her group were able to get a rough approximation of the traffic volume at that roundabout. These are a few of many instances Kim described as evidence supporting the influence of group interaction on her social engagements within the course.

2.5.4 Case study: Carter

Carter is a first-year graduate student pursuing his civil engineering doctorate. He completed his civil engineering bachelors’ degree at another institution. Carter is a goal-oriented individual, who stays focused to complete his course assignments and graduate research. Often times you can find him in his office working diligently, and is more than willing to provide assistance when you need it. He is sociable and collaborative while working in groups. His kind-hearted personality makes it easy to converse with him and make create friendships with others. Upon starting graduate school, Carter began participating in multiple student chapters on campus to network with his colleagues and engineering professionals in the field of civil engineering. When he is not working, Carter enjoys staying physically active and volunteering his time to the student chapters on campus.

2.5.4.1 About Carter’s transportation course

Carter was enrolled in the same course transportation course as Kim.

2.5.4.2 Carter’s social engagement in and out of class

The structure of lecture sessions in Carter’s course varied based on the topic. Classroom discussions and think, pair, share activities were used interchangeably with instructor presentations of lecture material to keep students engaged with the concepts taught in class. When Carter engaged in these discussions and activities, he chose to interact with a single person

or group in proximity to him because of convenience. Many of these interactions lasted for five to ten minutes, where Carter would collaborate with his peers by providing their thoughts regarding the discussion or activity topic, and were periodically asked to share these ideas with the class. On very few occasions did Carter ask questions during lecture, which was based on the elaborate description of the lecture material via presentation slides. Carter felt that the slides were able to answer majority of his questions, and chose to take verbatim notes from these slides to use in his review for course examinations.

Carter socially interacted with his peers on a regular basis in the laboratory session each week. Based on the instructor's request, students were asked to work with students they had not previously worked with in prior laboratory assignments. When asked about how he felt about this, he responded, "I'm still new and still trying to get to know people. So that forces that to happen when I might not be so willing to do so, otherwise". Carter's engagement with his group followed a common pattern, which started by gathering together and collect one another's contact information, followed by establishing a date and time to collect data outside-of-class. There were instances where Carter and his group opted to leave the laboratory session early to collect data as a group, while other times he would meet up days later. In the latter half of the course, Carter was given time to work with his project group in place of being issued a laboratory assignment. Carter and his project group would spend twenty to thirty minutes on average discussing what work had been and needed to be done. The instructor collaborated in one of these discussions, because Carter and his group were brainstorming possible solutions to help fix their trip generation and distribution plan.

Data collection for the laboratory assignments required Carter and his group to interact outside of class each week. He reported how each week was an entirely different experience, shaped by those that he worked with. For example, one week Carter was making observations and discussing his thoughts with his group members, and the next week he was helping collect vehicle times for a spot-speed study with an entirely different group of classmates. The complexity and structure of each assignment influenced what was required of Carter, and how he

chose to interact with his group. When they were not out collecting data, the group would be working on the written report. Majority of the time Carter would share a Google Document with his group members, where each member would write their assigned section of the report simultaneously if they so choose. Carter was able to interact with his group through this interface by placing comments, and editing the report in real-time.

When the laboratory assignments transitioned into project work, Carter began interacting more with his group outside of class. Together, they had to create a traffic impact study to predict the change in traffic flow after the construction of a hotel, restaurant, and shopping area had been completed. Carter and his group interacted by synthesizing the data collected previously in the laboratory assignments, coupled with new field data and a simulation of the new transportation network. Carter expressed how one of his group members, Josh, had completed a lot of the project work over the last few weeks of the term. This reduced both his workload on the project, which he utilized to help with the project presentation slides. Carter and his project group practiced their presentation twice on the day before the presentation was scheduled to be given. “We made some changes to the PowerPoint, edited a few things after the first go through. Then we ran through it again and it went a lot smoother the second time because we had the edits changed and everything”. This interaction allowed Carter and his group to polish their presentation slides and feel confident about their presentation the following day.

There were very few interactions between Carter and his peers regarding the homework assignments. He felt confident in his understanding of the material to complete the assignments without interacting with others. Because many of his classmates shared the same graduate office, he would occasionally spark a short conversation about a confusing part on a homework assignment, or to ask how far they had gotten. Additionally, Carter explained that he studied alone for the final examination, and only had a brief discussion with one other student an hour before the exam. “I had a brief discussion with Josh Anderson about the steps for creating a signal timing plan about an hour before the final. Other than that, I did not have any discussions with classmates regarding the final”.

2.5.4.3 Specific instance of Carter's engagement

Carter's engagement during the first laboratory assignment will be described in this section. During the laboratory session of week one, students were asked to find a group for their first assignment. Carter agreed to work with Josh and Cameron, who were sitting nearby. Together they looked over the laboratory assignment handout provided by the instructor, and discussed how and when they would collect their data. The assignment required students to make observations regarding user expectancy for three specific traffic intersections spread across town. "We still had about an hour-ish, maybe a little bit more left of the class block, so we decided we'd just go ahead and get started on the site visits for the lab because there were three that we needed to get through, two of them being in walking distance and one of them not being within walking distance". So the group left the classroom and walked to the first of two intersections for the day.

By the time that they had arrived at the first site, they had already discussed what kind of notes they wanted to make, and decided to take pictures so that they could be included in the laboratory report. In addition to note taking, Carter spent a large portion of time talking with his group members about each site. "Most of the time we were at the site, it was just talking through what we were seeing with less emphasis on note taking, more of just verbal observation with some note taking of some of the specifics we wanted to remember for the report, but overall just getting a general sense of the intersection". Carter estimated that they spent between 20 and 30 minutes at the first site before moving to the second site.

As with the first site, Carter talked through what he saw at the second site. He noticed a few potential problems with this site, because many of the houses nearby had driveways that faced the intersection, and had their own detection loop. "Most of it was just verbally discussing it and getting a sense for how the intersections worked and discussing problems. Even introducing Cameron to a couple of the concepts that he wasn't familiar with, like with the inductor loops and

things like that". Afterwards, they collected the notes and pictures needed for writing their report, and set a time to meet to observe the final site.

Later that week Josh drove the group to the last site. The group operated the same way as they had at the other two sites by pointing out various user expectancy issues and interesting characteristics of the site. After taking a few pictures for the report and quickly jotting down a few notes, the group drove back to campus and dispersed for the day.

From that point onward Carter did not interact with his group face to face. "We communicated through the chat function on Google Doc and Facebook just to organize who was doing what parts and making sure that all the parts would get done". On his own, Carter drew schematics of each site visited, wrote about one of the sites, and provided a conclusion that tied the report together. After he finished writing, he went through the document once more to edit and address any of the remaining comments before printing out the final report for submission.

2.5.4.4 Interpretation of Carter's engagement

This laboratory assignment was the first time that Carter had interacted with his classmates during the course. Over time, it was interesting to see how his interactions changed based on the group and the assignment requirements. Before taking this course, Carter had not interacted with anyone other than the instructor. When it came time to choose partners for the first laboratory assignment, he felt slightly uncomfortable deciding who to ask. This was Carter's first term as a graduate student in a new institution, and was being forced to work with students that he had not worked with before. As a result, he chose to work with those in proximity of him out of convenience. After working with Josh and Cameron, Carter explained his final thoughts on his interactions and with their report, "When you're working with new people you don't always know how that's going to go. That went very well. I was very excited". In the later laboratory assignments, Carter grouped with other students in the class, as requested by the course instructor, which allowed him to develop a social network of his peers. In a discussion between Carter and the course instructor outside of class, Carter mentioned that he would not have

interacted with all of students in class if he had not been asked by the instructor to do so. This opportunity helped broadened his social network, and he was able to learn more about his peers on a personal level. Because his laboratory groups changed each week, Carter had been able to collaborate with the members of his final project group prior to him knowing that they would be working together. Additionally, this allowed Carter to understand his final group members personally, making his conversation with them more comfortable. For example, Carter and his group members were able to efficiently divide out the work based on their strengths and interests by communicating that to one another. They maintained open communication throughout the project, which allowed them to troubleshoot errors in their work quickly and iterate their design as needed.

The way Carter interacted with Josh and Cameron in this laboratory assignment was also influenced by the assignment itself. This assignment did not require calculations, which differed from other assignments that required students to collect traffic counts, signal timing data, and perform signal warrant analysis. The structure of the assignment only required students to describe their thoughts about each site and any possible user expectancy issues that could arise, with no need to record any written notes or pictures unless the students chose to do so. In comparison, Carter's interacted the complete opposite during a later laboratory assignment. He stated, "[his partner] was the one primarily doing the timing with the stopwatch and I wrote down the times on the notepad. Once I got more comfortable with that, I also started doing times so it would take us less time to finish. It was a long process to do three runs for each of the phases". That assignment asked students to collect spot-speed data by timing vehicles as they pass a drive a specific length determined by the students. Carter's interaction was limited during the data collection because he was focused on collecting accurate data. Eventually, Carter did not even interact with his group until the rest of the data was collected.

Group interaction also played a role in Carter's interactions with his group. All three members worked together to verbally interact with one another by openly asking questions and pointing out interesting site characteristics to generate a discussion. They willingly collaborated to

construct new knowledge, which was later written in their assignment report, which added value to their discussion. Carter even had the opportunity to teach Cameron about the induction loops placed near intersections to detect vehicles. Throughout the course Carter recollected many positive interactions with his group members that reinforced his willingness to collaborate and complete the assignments as best he could. In one of the later laboratory assignments, Carter had wanted to learn how to use the traffic simulation software Synchro. One of his group members for that assignment went out of their way to help him learn it, even though they were responsible for completing the work themselves. “I told her I'd take over a little of the synchro stuff just because I wanted to know how to use the program because I hadn’t had an opportunity to do that yet. She was really helpful and walked me through some of the basic things to look at. I input some of the data into synchro... Then I was asking her several questions through that along the way”. Overall, the group interaction recollected by Carter motivated him to engage with his peers.

2.5.5 Case study: Mitchell

Mitchell is a second year masters’ student in civil engineering who plans on continuing to pursue his doctorate degree. He dedicates a large amount of his time to his research, studies, and developing his professional connections through the university and various extracurricular activities. Mitchell is always willing to listen, offer help and advice, and contributes valuable knowledge in his interactions with his colleagues and the researcher. While he can be quite personable, Mitchell tends to engage with his coursework individually, only reaching out when confused or after showing struggle over the assignment. This allows him to deepen his understanding with the concepts before receiving assistance. His confidence in the concepts and topics determine his level of engagement towards an assignment or studying for upcoming quizzes and exams. Because he is balancing research, coursework, and his personal life, he strives to work efficiently, but is willing to take the time to completely understand the topic before moving forward.

2.5.5.1 About Mitchell’s structures course

Mitchell enrolled in a graduate level seismic design course. Three 50-minute lecture sessions were held each week, spanning ten weeks in total. The course instructor led the lecture sessions by presenting PowerPoint slides to covering a variety of seismic-related concepts. PowerPoint slides with blank spaces were handed out in class to engage students in seismic terminology and help generate class discussion. Interaction with structural models and various small group activities were documented infrequently in class. Small group activities were rare in the course. The class congregated after some time and discussed them altogether, verifying the answers Mitchell had written in. Other small group activities yielded the same type of interaction.

Outside of class students were required to complete homework assignments, online quizzes, and prepare for a midterm and final examination. Homework assignments asked both conceptual and design-related questions. Five-question online quizzes were frequently assigned to test student's conceptual understanding and could be infinitely retaken. A midterm and final examination were conducted during the fifth and eleventh weeks of the term to evaluate student's understanding of the concepts taught throughout the course.

2.5.5.2 Mitchell's social engagement in and out of class

During in class discussion, Mitchell would occasionally speak up when he felt confident in his thought or to answer an instructor-asked question. "If I do provide an answer it's usually not like very vocal. I might like say something that I know if they can hear me say it, but the rest of the class can't necessarily hear me, which is good and bad. It's nice because it gives me the confidence to speak out and provide an answer, but if I'm wrong like my peers don't hear my wrong answer, and at the same time that shouldn't matter". Other times he would remain silent, because he knew that the instructor would answer their own question and continue lecturing.

Small group activities in Mitchell's course revolved around making observations of a structural model or completing a handout with a nearby classmate. He routinely sat in the first row of the classroom, and interacted with his closest neighbor. Mitchell described how they worked together to observe the stress acting on a structural model by saying, "we'd be like, 'Oh, you can

kind of see this 45 degree lines forming in the paper? There's crinkles folds in it and that's exactly what she wanted us to observe'". Over time the two became acquainted, but their interactions remained brief and to the point.

After talking with the professor outside of class, Mitchell was given the opportunity to share a structural model he had made with the class in the later weeks of the course. The instructor invited Mitchell up to the front at the end of a lecture session and had him explain torsion loading as he physically demonstrated it with another student from class. Many of the other students were fascinated with his model and talked with Mitchell afterwards. "A lot of them decided that was really cool. I guess that one student, Jeremy, came up to me and said, 'Yeah it's really neat, it's just like I like that a lot. I might go build one myself'".

Outside of class Mitchell frequently conversed with his classmate, Jeremy, regarding the homework assigned by the instructor. Mitchell shared his assumptions, calculations, and methods of solving the problems to clarify the work he had done, which made it easier for them to compare solutions. "I remember asking him what he got for his stories here at the roof and he had told me what he got and it was the same large number that I had". These conversations took place the day before the assignment was due so that Mitchell could go back and fix his work if it was done incorrectly.

There were times when Mitchell was confused about the concepts taught in class, and chose to converse with his classmates outside of class. The instructor was Mitchell's main choice for receiving help, because they understood the topic and was able to quickly understand his problems. There was once instance where the instructor was not in their office, so Mitchell chose to converse with a colleague, Amy, who is experienced in structural and seismic design. These interactions were straight to the point, and did not last long.

In preparation for the midterm examination Mitchell was asked by one of his friends in the course, Jennifer, to study together. Together they created a set of flashcards to quiz each other

and re-familiarize themselves with all of the course content. Once he felt confident in his understanding of the course material, he transitioned into studying alone up until the midterm examination. He did not interact with any of his peers in preparation for the final examination.

2.5.5.3 Specific instance of Mitchell's engagement

As the midterm examination quickly approached, Mitchell decided to meet with his classmate, Jennifer, to study together. They began studying together using the flashcards Jennifer had made prior to Mitchell's arrival. Mitchell briefly summarized his interaction with Jennifer by stating "At first I was holding the flash cards and I was asking her, 'What's the equation for this variable?' Then, she would say it and if she got it right then move on. If not, then it's just like, 'No, it's this.' That's purely all that was. I would do that for her and then as soon as I was done, she would use the cards and then she'd ask the same thing". After Mitchell felt confident in his ability to answer Jennifer's flashcards correctly, he decided to create another set of flashcards containing the major concepts and equations which he felt would be on the midterm examination. Mitchell convinced Jennifer to study using his flashcards, and they tested one another again. After they both answered all of the flashcards correctly, Mitchell decided to retake all of the online quizzes again, and Jennifer worked on the homework questions. The remainder of the time was spent working individually.

Days later, Mitchell went back over all of the flashcards that were previously studied, in addition to looking at the lecture notes, quiz solutions, and homework assignments to familiarize himself with all of the work that he had done in the class. He frequently checked his quiz and homework assignment feedback to better prepare for the examination. The morning of the examination, Mitchell was looking over the online quiz questions one final time and had gotten some of the questions were wrong. He felt that his answers were actually correct, so he decided to ask the instructor about them. The instructor quickly answered his questions and Mitchell began taking the examination.

2.5.5.4 Interpretation of Mitchell's engagement

Mitchell's choice to study with another classmate was quite different from his other social engagements throughout the course. He described his interactions with his classmates and the instructor being short in duration and to the point, where we would receive an answer to the questions he had and would resume working alone. However, his interaction with Jennifer spanned multiple hours and required collaboration to test one another and discuss the flashcard solutions. Mitchell described that he had not memorized via flashcards for a long time. "Normally, I don't have to memorize equations or anything like that so it was interesting". The act of testing one another using flashcards created a unique social engagement between Mitchell and Jennifer that influenced how Mitchell reinforced his existing knowledge. After a few iterations of flashcard testing, Mitchell was able to remember pick up on the correct answers and help test Jennifer's knowledge. Discussion between Mitchell and Jennifer when wrong answers were given provided additional opportunities for Mitchell to develop a better conceptual understanding. Eventually they were able to both answer every question correctly, and they transitioned into studying individually on different topics.

Until this point in the course, Mitchell had not worked with Jennifer. They had worked together in courses prior to this one, and felt that sharing information with one another would be mutually beneficial. Jennifer influenced how Mitchell engaged because he would not have created flashcards otherwise. "It was a little bit bizarre. I hadn't had to make flash cards for a class in a long time… It's not been a study strategy I'd used in a long while but it was easy to memorize them pretty quick". He was not forced to create flashcards, but chose to do so because that is what Jennifer had done. Mitchell decided to create his own flashcards after mastering the ones Jennifer had made, to include additional concepts that he felt needed to be studied in more depth. They were able to practice using Mitchell's flashcards, and he was able to help Jennifer memorize concepts that she might have not otherwise learned individually.

In preparation for the midterm examination Mitchell set aside more time to study. His motivation to score well encouraged him to interact with Jennifer to share knowledge. Because the question on the examination were unknown prior to taking it, the unknown difficulty of the examination

may have been another influence contributing to the engagements Mitchell described in the interview. In comparison, he explained how he spent more time studying for the midterm examination than most of the homework assignments and online quizzes. Even after interacting with Jennifer, Mitchell continued to study using flashcards over the days leading up to the examination.

2.5.6 Case study: James

James is a first year graduate student studying engineering. It is his hope that he can utilize the knowledge gained from this graduate degree to positively influence the engineering practice. He is seen as a kindhearted and driven peer among his colleagues, because he is always willing to put in the effort to get the work done. James's work ethic is driven by a balance of fairness in workload and competition with his classmates. He is very personable, and willing to speak up in the midst of confusion or difficulty. Additionally, James is involved with both professional and ethnic organizations through the university when he is not working on research or coursework. Regarding coursework, James believes that you will learn and grow from what you put into your work. He does honest and truthful work, which is expressed by his choice to determine solutions individually and mitigate any possibility of academic dishonesty.

2.5.6.1 About James's geotechnical course

The geotechnical course that James enrolled in meets twice a week for lecturing, with a lab session following directly after the first lecture of the week. Each of the lecture and laboratory sessions span a total of one hour and fifty minutes each. Upon arrival the first week, James counted eight students including himself enrolled in the course, with one teaching assistant to aid the course instructor.

Lecture sessions each week were led by the course instructor, and used as a time to discuss geotechnical concepts verbally while displaying supplemental material via projector and whiteboard. The supplemental material includes various equations and their derivations, graphs, and other relevant pictures. Students could ask questions informally during the presentation of

material, but a formal question and answer session was included at the end of each lecture session.

The laboratory sessions would begin with the teaching assistant walking James and his classmates through the lab, explaining how to properly use the equipment required in the current experiment. With the remaining time, students were encouraged to begin working on the laboratory assignment in their assigned groups. James and his classmates were allowed back in the laboratory during non-scheduled hours of the day to complete their experiments.

Outside of class, students worked on their individual laboratory report. There were no homework assignments required in this course. A final examination tested students on all of the concepts taught throughout the course on the last week of the course.

2.5.6.2 James's social engagements in and out of class

James primarily kept to himself when in the lecture sessions, because he was focused on taking notes of the presented material. However, there were cases where James would speak up to ask a question during the middle or end of a lecture to gain clarification of a topic or figure. These interactions were directed towards the instructor and were commonly answered within a minute or two before continuing their presentation. At the halfway point of the lecture session students were given a five-minute break, and James occasionally used that time to converse with his four-person laboratory group to schedule their next out of class meeting in the laboratory to continue their work on the laboratory assignment.

During the introductory walkthrough of the laboratory equipment given by the teaching assistant, James chose to listen and take notes instead of asking questions. James would then meet with his group after the walkthrough to determine whether they had time to begin the assignment at that point or schedule another time to meet and get started. When his group decided that they would work in class, James interacted in one of three ways. Firstly, James would commonly read the laboratory methodology and supporting literature provided by the instructor, followed by asking

his group members questions regarding what he read. Secondly, James would use his knowledge from the literature to begin executing the experiment. Many of the experiments required multiple people to work together to operate the equipment and collect the results. James briefly explained how he worked together with a group member in one of the earlier laboratory assignments in the course, “I started getting on the method B and the rest of the group joined me maybe 10-15 minutes later. They could verify that I had programmed it correctly. We went through and I showed them the steps, ‘Here's where I added all the different loads’...”. Finally, James would interact with the teaching assistant in class when his group could not help him answer a question that he had. The questions James had for the teaching assistant were strictly about methodology and confusion between how other geotechnical research tested their samples as compared to that of their own experiment. He would download the data or files that he was confused about on a USB drive and share it with the teaching assistant to help them understand his question. Occasionally there would be times where the teaching assistant did not have the right answer for him, and he would resort to the recommended literature once more.

The majority of James’s interactions took place outside of class with his laboratory group, due to the difficulty and complexity of the assignments. Each experiment required collaboration between James and his group to carefully collect data while operating a variety of different laboratory equipment. In preparation for these experiments, James routinely read through the instructor’s recommended readings and the findings from recent literature in engineering practice. Reading ahead allowed James to feel confident in his ability to converse about the experiment, and speed up the analysis process later on. Once James and his group were past the preparatory phases of the experiment, he interacted with his group while using computer software to collect data, to accurately weigh and measure soil samples, and troubleshooting errors in the previous work done. His interactions typically were short and focused on completing a specific task. An example of this reads, “There was a switch here that you could read cell pressure and then core pressure. We switched it here, then the person here would read it. It would show up on the computer… Then they got those values, copied and pasted them into the Mathcad file”. After the data collection had been completed, James completed his analysis

and written report individually. To prepare for the final examination, James studied alone by looking over all of the material covered throughout the course.

2.5.6.3 Specific instance of James's engagement

The final laboratory assignment will be described in this section as it represents how James frequently interacted with his peers throughout the term. The laboratory assignment began the day before Thanksgiving break. The assignment required James and his group to saturate three soil trials using a combination of manual and automatic pressurizing methods (one trial of each method at a minimum). That morning James met with two of his group members to begin the experiment. After spending some time reading the assignment outline and supporting literature, James was asked to help prepare a soil sample for the automatic procedure. To prepare the sample, a container filled with soil and water had to be vacuum sealed inside a pressurizing module. "In the beginning I was mostly stumbling through the processes. One of my lab partners, at least, had a better handle on it, I felt. I was mostly doing, turning the knobs, observing what was going where, and preparing the specimen… When it came to applying the vacuums, saturating the specimen, I wasn't as comfortable so I would kind of take a backseat but participate where I could". Towards the end of their sample preparation, they came across a leak in their vacuum seal, causing the sample pressure output to spike. The sample was set aside, and James chose to read about the automatic testing procedure. James and his group decided that they were too tired to continue their sample preparation and left for the Thanksgiving break.

Remembering that they still had two more samples to test, James and his group emailed one another and decided to meet the upcoming Sunday to continue working. That morning they met in the laboratory to check on the sample they had put in on Wednesday, and prepare the second sample for the manual using the manual method. "It was like eight hours that day, on Sunday. That one was preparing ... Because this one had leaked on Wednesday, we prepared that specimen again and did it on Sunday". By the end of the day James and his group had worked together to troubleshoot the leaking problem, with no success, but managed to have one sample prepared for the manual test ran the following day.

In lecture on Monday morning, James and his classmates convinced the instructor to let them conduct three tests using the manual method because of how much trouble they had ran into over the weekend. A time extension was given to the class to allow enough time to collect the test results and complete their written reports. Over the next two days, James met with his group for multiple hours each day to finish preparing, testing, and collecting data following the manual method. The manual method required James to work with his group members by repeatedly modifying the pressure placed on the soil and reading the results from a computer software outputting these readings. James described the process, “It was open communication. For example, the saturation part, we had to do it in increments, like change the different pressures, change the cell and core pressures only incrementally to get a better saturation value. But we couldn't increase one of these pressures eventually over 400 kilopascals, so we had to discuss what's the best way to get this saturation value without doing these steps”. James interacted with his group by recording the data output from the computer into a Mathcad file, where he would then tell one of his group members to close the primary on/off valves. The pressure would then change over a five minute timespan and another recording would be displayed. Once the soil samples reached the maximum pressure required, James would help his group move the sample to sit overnight. This process occurred three times throughout Monday and Tuesday, leaving Wednesday available for James and his group to collect a final sample reading before parting ways to write their individual laboratory reports.

2.5.6.4 Interpretation of James’s engagement

Many of the laboratory assignments prior exhibit similar factors influencing James’s social interaction with his peers. James’s group remained the same throughout the entire course, allowing him to develop connections with these students that he might not have done otherwise.

The first day James began working on the laboratory assignment he described how his confidence influenced how he chose to participate during the laboratory assignment. “In the beginning I was mostly stumbling through the processes. One of my lab partners, at least, had a

better handle on it… When it came to applying the vacuums, saturating the specimen, I wasn't as comfortable so I would kind of take a backseat but participate where I could". James felt that he was not confident in his ability to apply a vacuum was due to his understanding of the laboratory itself and having no prior experience doing so. The lack of confidence James experienced helped motivate him to engage with the laboratory methodologies and related literature to familiarize himself with tests similar to the one he was conducting. By reading and understanding related literature, James felt that he could contribute his knowledge to help complete the laboratory assignment with his group. This was also paired with the feeling of guilt, as one of James's group members had practical experience with geotechnical testing and led many of the laboratory assignments throughout the course. "In my group of four people, only one person has actually experience in the geotech doing undergrad research… Whereas the other three of us, we still had to ... We hadn't become familiarized with it". James aspired to be a contributing member of the group. These motivations led to James's frequent interactions with the experienced member of his group, and to collaborate with the rest of his group to collect accurate data following the methods outlined by the laboratory assignment.

Laboratory assignment difficulty contributed to a more frequent interaction between James and his group. The difficulty first took place in James's engagement with the automatic testing software. "There was a binder there that we could use to operate the software. There were gaps in it. It said, 'Open this window and set these parameters.' Well, once you opened the window, there's no place to fill in those numbers for parameters". During the Sunday of Thanksgiving break, James explained how the other group of students attempted to test a sample using the automatic equipment with no luck, and the class convinced the instructor to change the laboratory assignment requirements to allow for only manual testing.

James also experienced difficulty with sample preparation with his group. His first attempt at preparing the soil samples sprung a leak in the vacuum, meaning they were unable to use the data and the sample was disposed. Other difficulties in sample preparation included over-consolidation, and using pressures over 400 kilopascals, which are a unit of pressure exerted on

the soil sample. These stipulations influenced James's interactions with his group because they were constantly communicating with one another to successfully prepare each of the three samples. Data collection emulated many of these same interactions. For example, "When I said something like, 'Close the primary on/off valves,' we'd all agree with it, 'It's this one? Okay. Switching it? Okay.' So we all had a consensus".

The structuring of the laboratory assignment also influenced James's interactions. Each of the three tests required a sample to be prepared. These samples took approximately 30 minutes to prepare, and required their undivided attention. Testing of each sample took less time, but James needed to keep open communication with his group as they operated the geotechnical equipment. "Most of those increments were waiting two or three minutes. So we did the switching and turning knobs and stuff, which only took 30 seconds or something; had him read the values, saying, 'Okay, our value is 76%. Let's increment it another 10 psi.' Then we did this again…". It took James and his group over a week, meeting majority of the days, to complete the data collection. Interactions in James's other laboratory assignments were less frequent because they were structured to take less time to conduct and relied on automatic equipment instead of manual equipment.

2.5.7 Case study: Kacie

Kacie is an undergraduate engineering student studying both civil and forestry engineering. She is planned to finish her dual degree program by the end of the 2016 academic year. Kacie is viewed by her peers as a kindhearted and personable individual who is always willing to help others. She is a friend of many students in her majors, and is frequently seen conversing with them. Additionally, Kacie efficiently manages her time by planning ahead and working with others when the opportunity arises. During group projects, Kristina works hard to create a quality product, while also taking the time to collaborate with her group members so that everyone is in agreeance. When she is not studying, Kacie spends time participating in academic groups led by the university as a social outlet to meet establish new connections with others. Her kind personality makes it easy to converse and work with her.

2.5.7.1 About Kacie's capstone design course

Kacie enrolled in the civil engineering capstone design course, as required by all civil engineering students before graduation. This course spans two ten-week courses, comprised of two 50-minute lecture sessions and a single one-hour and 50-minute recitation session each week. During the second week of the course, students were assigned project groups based on their responses from an in class survey asking students for their top choices in projects, to describe any technical skills acquired, and the discipline of interest. Disciplines include geomatics, geotechnical, transportation, structural, and hydrologic design. Groups remained together throughout both ten-week courses, and were responsible for presenting their final project design to an engineering panel.

Lecture sessions began by preparing students for upcoming assignments and deadlines. Short presentations were given to discussing assignment requirements by the instructor, followed by an open question and answer period regarding any topic the students needed help with. When the question and answer sessions concluded, students would be dismissed for the day.

Recitation sessions provided an opportunity for students to complete course assignments as a group. The recitation classroom was equipped with a desktop computer for each group. Additionally, standardized manuals and engineering literature were provided for student use, and a four-person instructional team helped to answer questions as needed.

Course assignments not completed in the recitation session were worked on outside of class. Both individual and group-based assignments were designed to help students construct a group project report that would be submitted by the end of each ten-week course. Group presentations in front of practicing engineers occurred during the tenth week of each course.

2.5.7.2 Kacie's social engagement in and out of class

Kacie found herself interacting with a variety of her peers throughout the capstone design course. In the lecture sessions, Kacie commonly sat near classmates that she had known from previous courses. She asked very few questions during lecture, but found herself interacting with her group members and other friends during the small handful of in class discussions. One instance in particular, Kacie explained that she was conversing with a group of six other students as they talked about the relation of their group projects to engineering practice. “The only people I talked to were my group mates, and some other forestry kids were there, too. It was just joking and laughing in the beginning. Then, it was more discussion on why we thought this was a good class. Amanda was the closest one to me, so I was mostly talking to Amanda, and then some of the people around us would chime in too”. They engaged by sharing their opinions one at a time, so that they would all have a chance to build off of each other’s thoughts. Kacie also engaged during lecture by working with her group members during in class activities. Together, the group was able to construct a table of design alternatives based on a set of variables deemed important by Kacie and her group members. As a group, they were able to share their plan with the rest of the class.

A majority of Kacie’s social engagement took place during the in-class recitation period. In the beginning of the course, Kacie primarily collaborated with her group members to research different design alternatives, and complete various course assignments aimed to help them prepare for the engineering panel presentations at the end of each term. Later in the course Kacie’s interactions with her group members shifted into a discussion about the alignment of her geotechnical design with that of the transportation and hydrologic designs. There was one instance in particular where Kacie needed to compare her work and assumptions to her group’s to make sure that they aligned. She stated, “I was looking over my flow rates again because they were a little lower than Amanda's. She has a lot larger flow rate than I do just using the material I've found. We went through my spreadsheet together and looked at everything and changed some of my numbers and realized ... I'm just asking them quick questions when I'd name it in the past just like, "Okay what'd you guys do for this?". These interactions were dependent on the questions that she asked and if her group was able to help her. Other times Kacie would interact

with the instructional team or other classmates during recitation when she could not come up with an answer herself. Teaching assistants were available each week in the recitation period, which Kacie conversed with regularly to ask for their design recommendations and clarification. By the end of the course Kacie and her group had successfully completed their engineering design and spent the remainder of their time developing presentation slides for the engineering panel presentation.

Outside of class Kacie continued working on her group project by reaching out to engineering instructors that she had befriended, in addition to the course instructor and her group members. Kacie's choice for enrolling the help of three previous instructors was due to their field of study, as they corresponded to the work she was responsible for on the group project. She explained one of her interactions by saying, "I kind of told him my concerns of the water flowing up and over, and that's when he just pulled the document out right there, 'Actually, this is perfect for you,' and he flipped to the page and was just like, okay. He just said, 'If you read this part of the manual, you can see how they're talking about the over topping'". The interactions she had with these instructors provided her with supplemental thought and literature regarding possible design alternatives to consider for her group project. Kacie primarily conversed with the capstone course instructor via email communication about data acquisition at the start of the course.

There were several occasions when Kacie needed to work with her group out of class to complete their group design report and practice their presentation slides. The collective information for Kacie and her group's work was placed in a group design report outlining their chosen engineering design and the calculations supporting its feasibility. Kacie interacted with her group to create the group design report by discussing the edits she had made in their writing, and working with her group member Amanda to create multiple figures using AutoCAD software to provide a visual representation of their chosen design. "On Thursday I just kind of ran into Amanda at the computer lab so we started [working on] my ... design that I did, a figure for the poster… Her skills in AutoCAD are significantly better than mine so we just kind of sat down and looked at my design in AutoCAD and we just kind of tweaked it". In preparation for

their presentation given every ten weeks, Kacie spent a few hours creating and practicing their presentation slides. Together they would cluster around a single computer and took turns leading the conversation about what should be discussed during the geotechnical, transportation, and hydrologic design sections. Afterwards, Kacie practiced presenting alongside her group members until they felt confident enough in the structure of their presentation.

2.5.7.3 Specific instance of Kacie's engagement

By the fourth week of the capstone design course, Kacie was required to submit an outline describing the layout of her individual design report covering the geotechnical design of her project. Following the submittal of her outline, Kacie was required to review another student's outline who was assigned the same project, but was a member of a different group. The interaction between Kacie and her peer review partner, Anthony, took place during an in class recitation session.

Kacie arrived to the recitation session with a copy of Anthony's outline with comments that she had made throughout. Once the session began, students were asked to find those they had been paired up with and to share their thoughts and help develop each other's outlines. "At first it was a little unorganized and hectic, but it was actually really nice talking to someone outside of my group". They started off by reviewing Anthony's outline, where Kacie shared the comments she made prior to class, which became conversation points that Anthony addressed. Once Kacie finished sharing her comments they moved to her outline, where the same type of engagement occurred. "The comments were very general and basic like, oh you could have, you know like, it was pretty basic comments, but then when we actually started talking to each other we gave really good feedback". Kacie asked Anthony a series of questions his thoughts on the project, and what his team had considered as possible design alternatives. Many of the ideas that Anthony shared with Kacie helped her to see other alternatives that could be a viable option.

Kacie chose to jot down notes of her conversation with Anthony, which she later brought to her group to discuss. The peer review session lasted for forty minutes of a one-hour and fifty minute

recitation session. Kacie used the remainder of the session to continue developing her individual design report outline.

2.5.7.4 Interpretation of Kacie's engagement

The peer review assignment was constructed to give students working on the same project an opportunity to discuss with those not in their immediate group. Kacie was randomly paired with another student, Anthony, whom she actually knew previously. Kacie mentioned how she knew Anthony by stating, "He's an FECE as well, so we've had the same geo tech classes, so he knows exactly what my history class-wise is doing that". Because they had taken multiple courses together previously, Anthony shared much of the same geotechnical engineering knowledge as Kacie. She was able to benefit from this shared knowledge because they made discussion regarding their previous coursework as it related to different geotechnical design alternatives for their project. "One thing, since we do have the same project is, we talked about our constraints and existing conditions. I realized when I was reading his that I kind of missed what the question was, where the constraints and existing conditions". Anthony's willingness to help Kacie with her outline created a more meaningful social engagement. Additionally, Kacie reciprocated by answering all of his questions to the best of her ability.

The peer review assignment shaped the way Kacie engaged. Having to submit her outline prior to their interaction, Kacie had time to prepare comments for Anthony and additional questions regarding her own outline. "After writing my review I kind of realized that maybe I kind of thought I knew where I was going, then actually typing up my review and doing all of it kind of, I was kind of like, 'Oh wait. Where exactly am I going with this?'". The peer review in person during recitation allowed Kacie to ask Anthony how she should continue to develop her outline. Had this not been the case, Kacie's design report may have resulted quite differently.

Kacie's motivations and interests are factors which influenced the outcome of this engagement. As stated earlier, Kacie came into the recitation session confused about how she should construct the design report later in the term. This confusion was not for a lack of trying, as she had

produced an outline, but wanted additional feedback to mold it into a more refined product. The questions she asked Anthony later in their discussion were not necessarily prepared, but based on her motivation to understand and learn from the assignment. Their interaction gave Kacie a lot of new information to ponder and build off of. “I found it more helpful than I thought it was going to be, so I'm glad we did that”. The notes Kacie had written based on their conversation were later shared with her group members, which could imply that her interest in her group’s success is a priority. Because these new alternatives that had not been discussed in Kacie’s group, it motivated her to bring that information to them. Thus, Kacie’s interaction with Anthony spurred more interaction with other students afterwards.

2.5.8 Summary of social engagement across all case studies

In summary, student engagement were recollected from the perspective of seven students representing six different civil engineering and computer science courses. Steven enrolled in a graduate level GIS course with the intent of becoming competent in the ArcGIS software taught throughout the course. The course was primarily computer based, where Steven and his classmates developed different land use maps to evaluate different criteria. Steven frequently interacted with the teaching assistant and his neighbors in the laboratory session to help troubleshoot software issues he was having, and to provide clarity with course concepts. He infrequently interacted with a classmate he knew outside of class to prepare for half of the in class quizzes spaced throughout the course. It was Steven’s interest in the course and his drive to become competent with the ArcGIS software that encouraged his social interactions with the teaching assistant and his classmates.

Daniel chose to describe his engagements in an undergraduate level computer science course that he was taking for the second time. In lecture he sat quietly and listened to the instructor present, taking note of new or interesting points. During the laboratory sessions Daniel met and began working with his neighbor to complete the weekly laboratory assignments in class. When Daniel or his lab partner would fall behind or come to class late, the other would provide hints to get started, and make sure that they stayed on track before they left for the day. Many of the

laboratory assignments were completed in class, however some were completed outside of class. Daniel had to complete a final project which integrated many of the concepts that he had learned throughout the course, and chose to primarily work alone on it. The course structure and expectations made it so that Daniel could not share code, which influenced his choice of how he interacted with others in the course. Having taken the course a second time, Daniel felt confident in his ability to complete the assignments on time and with enough quality to pass the course.

Kim shared her engagements within a graduate level transportation course. During lecture she would sit near Evan, a classmate and friend who had worked with her in prior courses, and frequently talked with one another about the lecture material. In the laboratory sessions, students were asked to group with different classmates each week, encouraging Kim to interact with other people regularly. Laboratory assignments required students to observe and collect data outside of class, which is where Kim primarily collaborated with her group members. Group interactions that took place outside of class involved physical use of transportation-related equipment and discussion of traffic observations and results. Halfway through the course Kim was assigned a permanent group for a final project centered on the traffic impact once a restaurant, storefront, and hotel complex had completed its hypothetical construction in town. Kim worked together with her project group over the last half of the term to collect field data, develop a microsimulation of the traffic network, and write a final report summarizing the findings. Kim's willingness to collaborate with others, and her motivation to produce high quality work in the course encouraged frequent interaction with the course instructor and her classmates.

Carter was enrolled in the same graduate level transportation course as Kim. In class, he chose to only engage with those around him when he was asked to do so by the instructor. When it came to forming groups for the laboratory assignments, Carter knew very few people in the course. This made it difficult for him to interact with others initially, as he chose to say little, but he felt more comfortable with group interactions as the term progressed. Like Kim, most of Carter's engagement took place outside of class with his group members. It was Carter's willingness to meet new people and collaborate that influenced the way he engaged in the course.

Mitchell described his engagement in a graduate level structural engineering course. Lecture sessions were primarily structured around instructor presentations, but occasionally Mitchell was able to interact with a neighbor during in class activities and discussions. Because lecture sessions were the only in class environment, many of Mitchell's engagements took place outside of class. He mentioned interacting with the course instructor in their office about the lecture topics and how they were interesting, comparing homework problems with his classmate Jeremy, and studying with another classmate Jennifer for the midterm examination. However, Mitchell decided to wait until the final day to complete his homework and online quizzes, which influenced his ability to receive feedback from his peers and take the time to understand the homework problems fully.

James enrolled in a graduate level geotechnical engineering course to help fulfill his master's degree course requirements. The eight students in the course were divided into groups of four, which were responsible for conducting laboratory assignments together weekly. The lecture sessions each week pertained to the current laboratory assignment, and James made sure to speak out when he was confused about what was being taught in class. During the laboratory assignments he interacted primarily with his group members, but also asked the teaching assistant and the other group of four students questions when James and his group needed clarification or assistance. James and his group collaborated by performing physical experiments while discussing the process and findings as they worked. James persevered through what he described as a difficult course by working extremely hard with his group members and recruiting the aid of the instructional team or the other group of four students in the course as needed.

Kacie shared her engagement in a two-term undergraduate level capstone design course. Lecture sessions were used to discuss upcoming assignments and answer student questions. Once a term Kacie interacted with her neighboring classmates, which were friends that she had worked with in prior courses, to answer discussion questions prompted by the course instructor. Majority of Kacie's engagement pertained to her interaction with her assigned project group during the in

class recitation sessions and outside of class. During recitation, Kacie and her group would begin their work on course assignments by sharing a single computer and taking turns inputting their thoughts into the group discussion and the written document online. Outside of class Kacie was responsible for designing the soil reinforcement and bedrock for their roadway project that was prone to flooding in the wet months of the year. As she iterated her design she shared it with her group members, the instructional team, previous instructors that she had networked with, and a panel of practicing engineers to gain valuable feedback and insight. Kacie's interest in the course, accessibility to a broad social network, and her motivation to seek feedback through interaction that led to her academic success on her design and the group project as a whole.

2.6. Discussion

2.6.1 How students engaged in a course

Participants reported their student engagement in and out of a course by describing the environment in which the engagement took place, how they engaged, and the result of their engagement. When comparing the engagements of these students in their respective courses, it became apparent that there were both similarities and differences in the ways that they engaged and the reasoning behind doing so. Reported engagements from the participants suggest that student engagement differs by the learning environment, the task or assignment, and the reason behind their engagement, and relate to the research findings of Vermunt [8].

Participants described their interaction with their peers and the instructional team inside of the class quite differently than outside of class. In-class discussions and activities had participants collaborating with their neighbor(s), whether it was a long-time friend of theirs or someone they had never met before. There were times when the students were asked to answer a question during the instructor's lecture presentation, and other times where they raised their own questions to the instructor. Recitation or laboratory sessions were required in many of the participant's courses, and provided another learning environment for students to implement the concepts taught in the lecture sessions. The participants described both group, more than two

people, and individual interactions with their peers occurring more frequently during recitation and laboratory sessions than in lecture sessions. These interactions in the recitation and laboratory sessions were often times focused towards completing an assignment. Participants collaborated with their group by operating various software or laboratory equipment to produce the final deliverables for their assignment. Many of the participants recalled helping or lending aid to another student during the recitation or laboratory sessions by answering questions or providing clarity to the concepts taught in class.

Participant interactions taking place outside of class contained both similarities and differences from in class interactions reported. Many of the courses described did not allocate enough time in class to complete assignments, so the students were expected to continue their work outside of class. Participants had to schedule meeting times with their peers via email or personal communication continue their work on course assignments started in class. The constraints of assignment deadlines and individual schedules for group members affected how participants engaged. Leading up to the deadline of an assignment or examination, many of the participants reviewed their notes or assignment requirements, spent time writing and editing the work of others, and addressing any last minute problems within their groups or individuals. Throughout the students' courses, many expressed at least one engagement with a peer outside of class that resulted in a learning or teaching opportunity. Participants used laboratory equipment, engineering-related software, and supplemental documents provided by the course instructor while discussing with their peers to facilitate a learning experience. The result of these experiences encouraged future interactions with those peers, as many participants shared that they felt glad to have had that engagement. Four participants also interacted with the instructional team and other engineering professionals outside of class. Meetings were established over email communication, and the students prepared questions to ask. Some questions that were asked by participants required feedback on their work, and others generated even more discussion. Table 2.5 lists the ways that the participants engages in and outside of a course based on their self-reported experiences.

Table 2.5 Examples of student engagement inside and outside of a course

Learning Environment	Students Socially Engaged By
Lecture session	• Interacting with those in close proximity to the student • Interacting with those that he/she knew prior to the enrolled course • Collaborating with the same person throughout the course during lecture • Contributing to a class-wide discussion after conversing with their peers
Recitation/Laboratory session	• Sharing a single computer as a group while discussing an assignment • Working together to perform laboratory experiments • Helping a peer understand the concepts behind a laboratory assignment • Asking for help from the instructional team
Outside of class	• Conducting a traffic study with a small group of students • Preparing for an examination with a classmate • Learning how to use engineering software from a classmate • Emailing/meeting with the course instructor

2.6.2 Influence of contextual factors and individual characteristics on student engagement

Interpretation of student engagement in and out of a course led the researcher to a series of individual characteristics and contextual factors that have influenced how and why they engaged. Individual characteristics such as interest and perceived value of engagement, individual motivations, work ethic, previous knowledge, self-confidence, willingness to collaborate, and the preference to work individually, influenced how students chose to engage. Many of these findings reinforce those determined in prior research [7], [10], [11], [16], [17], [24], [30]. The

characteristics mentioned were not all applicable to a specific participant, but were interpreted across all participants. Interest and perceived value towards a topic or assignment encouraged participants to engage more frequently with their peers. For instance, Kacie chose to design the geotechnical reinforcement infrastructure for the roadway project she was assigned to because of her interest in the field of geotechnical engineering. She chose to engage with geotechnical and roadway professors to compare her work with their recommendations for design alternatives. Other participants described how they were given the opportunity to pursue their interests during group assignments by taking on work associated with said interest.

Motivation and work ethic were interpreted based on how the participants described their engagements. Some expressed enthusiasm regarding specific engagements, and disappointment or unhappiness with others. The presence and lack of motivation and work ethic were found across participant engagements. One example supporting work ethic is Daniels interaction with his lab partner and teaching assistant. Each week Daniel began the laboratory session by discussing with his lab partner the ways that they could complete the laboratory assignment. As they made progress or struggled with errors in the code, they would stop and talk with one another. Once Daniel reached a milestone in the assignment, he brought his work forward to the teaching assistant for feedback. This was an iterative process that continued until the end of the laboratory session. Comparatively, Daniel's motivation to complete his work outside of class differed from that of in class. He frequently worked during the final day to complete the assignment before submitting it online, which made it difficult for Daniel to collaborate or ask for help when he needed it. Other participants shared similar and different engagements related to motivation and work ethic.

The confidence possessed by participants was explicitly described by James during his laboratory assignments recollection. He chose to engage with his group to perform the laboratory experiment once he felt confident in his ability to help collect reliable and accurate data. Mitchell alluded to confidence when he spoke about his choice to speak up during lecture discussions only when he felt confident in his thoughts. Previous knowledge of course concepts was very

influential in the way each participant engaged. Daniel was enrolled in a course that he had previously taken, which made it easier for him to understand the material discussed throughout. When compared to the other participants, many of the topics covered in the lecture sessions and homework assignments were new to them. The lack of previous knowledge of the subject encouraged participants to interact with their peers and the instructional team to construct new knowledge. An individual's willingness to collaborate and their preference towards working individually were mentioned during participant interviews. Specifically, Kim, Mitchell, and James described that they could work more efficiently while working alone, but peer interactions does allow for clarity of confusing components of course assignments and concepts.

Contextual factors were both explained by the participants and derived using researcher interpretation of student engagements. Factors such as course and assignment difficulty, course expectations, course structure, group interaction, social norms, social network, and class size were found to influence the ways in which students engaged. Course and assignment difficulty was stated outright by some students, saying that they interacted with an individual or group more often to achieve academic success. For other students, the difficulty associated with a course or assignment was not explicitly stated, but was interpreted by the researcher because of the reasons these students chose to engage. Course expectations and structure are factors that influence student engagement by encouraging students to engage in a specific manner. For example, in James's geotechnical course, he was required to work with a group of students to collect experimental data and then produce a written report individually. It was expected that students would willfully collaborate with one another to achieve a specific goal, and the structure of the assignment created the environment for group interaction. Students alluded to course expectations and structure shaping their engagement by mentioning how the goals and outcomes for the course, and the assignment requirements led them to engage in a particular manner. Steven, James, Kacie, Carter, and Kim shared at least a single experience of them interacting with a group of students at once.

By describing how the interaction took place, how their peers made them feel, and the results from their interaction, the researcher was able to understand how the role of group interaction influenced student engagement. Group interactions were different for those who engaged with a group of students only once during a course as opposed to a group that met regularly. Additionally, group interactions were influenced by the social norms of the learning environment and the social network of the student. Social norms were implicitly described during participant interaction with their peers, which differed between learning environments, and supports the findings of Bourdieu [36]. To elaborate, participants interacted differently with their course instructors when in class and out of class, and is partially attributed to the change in the rules of engagement. Frequent interaction with the same group members and individuals throughout the course led to the development of a participant's social network. Participant engagement with those that they knew prior to the study were often longer in duration than those new to them. Relational qualities such as comfortability and trust formed as participants interacted with the same group or individuals, which encouraged participants to more willingly help one another and ask questions when struggling. This finding reinforces the use of resources embedded within the participant's social network, which Lin et al. [20], [21] described at length. Relating to group interaction and social norms, the number of students enrolled in a course was interpreted in being influential to student engagement. When comparing James' classroom size of eight students to Daniel's classroom size that exceeded one hundred students, there were both similarities and differences between their engagements. James described his classroom setting to be more personalized, allowing him to freely ask questions and receive feedback. However, the lack of students forced James into one of two laboratory groups. Conversely, Daniel did not have the same freedom to ask questions and interact with his peers in class. The remainder of participants enrolled in courses that fell in between these two extremes, resulting in both similar and unique engagements to the others. Table 2.6 lists the individual characteristics and contextual factors interpreted through participant engagements.

Table 2.6 Contextual factors and individual characteristics interpreted from student engagement

Individual Characteristics	Contextual factors
Interest and perceived value	Group interaction
Work ethic	Course and assignment difficulty
Willingness to collaborate	Social norms
Preference to work individually	Course structure
Motivation	Social network
Previous knowledge	Class size
Confidence	Course expectations

The findings of this research suggest a number of factors that may have influenced the participant's social engagement with their classmates and instructional team in a course. Course-related factors such as the structure, difficulty, and access to knowledge, in addition to instructor expectations and social norms were explained throughout participant interviews, and will be covered in more detail below.

The structure of a course is comprised of the types of learning environment and assignments that students are required to engage with. Each course described in this study was structured differently from the others, which may influence the way student social engagement with a course. For example, Mitchell's structural engineering course required students to attend three weekly lecture sessions, alongside individual homework assignments, online quizzes, with a midterm and final examination. Conversely, James's geotechnical engineering course required students to take part in two weekly lecture sessions and a laboratory session. James had weekly laboratory assignments, where data was collected as a group and reported individually, while also partaking in a midterm and final examination. While these course structures share some similarity with one another, there are a few key differences which influenced the student's social engagement within the course.

One primary difference between James and Mitchell's course structures were the ways each learning environment promoted engagement. James's geotechnical engineering course offered both lecture and recitation sessions, where James applied his knowledge from the lecture sessions with his group in the laboratory session to complete their weekly assignment. The instructor created PowerPoint presentations which provided mathematical derivations and graphs of geotechnical relationships to supplement their verbal lecture. Presenting both verbal and visual information helped James understand what was being taught during lecture, and they were encouraged to ask questions when needed. Mitchell's course differed as his only opportunity to socially engage in class was during the lecture sessions. When Mitchell discussed his engagement in class, the instructor primarily lectured using a PowerPoint presentation. Sporadically throughout each lecture the instructor would ask the class for the answer to a structural engineering question that coincided with blank spaces in the PowerPoint presentation. On rare occasions Mitchell was asked to collaborate with nearby classmates when pertaining to in class activities or discussions. One example of Mitchell's social engagement in class was during the sixth week of the course where he was asked to work with his neighbor to build a structure to model shear loading out of Popsicle sticks. As Mitchell constructed the model with his neighboring classmate watching, the instructor asked them to answer a series of conceptual questions verbally with one another. Mitchell and his neighbor quickly shared their thoughts in a sentence or two, and then remained quiet to listen for the next question. Each question escalated into a class wide discussion, where Mitchell was not chosen or opted to respond. After five conceptual questions the instructor shifted their discussion to continue lecturing via their PowerPoint presentation, and the models were given back at the end of the session.

While the development of physical models in Mitchell's course may have addressed the level of detail that his course instructor had wanted, the in class activity and discussion could have been structured in a way that encouraged more meaningful social interaction between Mitchell, his classmates, and the instructor. To prove this point, James described in his interviews that the laboratory sessions proved to be a great opportunity for him to interact with his group members, the other laboratory group of classmates, and the teaching assistant because he was constantly

applying the knowledge learned during the lecture sessions and his work outside of class. Had Mitchell received the same opportunity to work in a group of students, he might have been able to produce a larger structural model in a laboratory, or answer questions that required critical thought, which could encourage social engagement in similar ways James experienced. However, it is not necessarily the laboratory session itself that encourages social engagement, but the act of students critically thinking and applying the knowledge they have learned in the course to an assignment. Similar to the ways James engaged with his laboratory group throughout the geotechnical engineering course, Mitchell could have been encouraged to socially engage in meaningful ways with the students of his class and the instructor had they needed to apply their previous knowledge to collect laboratory data and operate structural engineering equipment.

Based on the findings from this study, instructors could modify their course structure to promote the social engagement of their students in a couple ways. Firstly, lecture sessions that integrate in-class activities or discussions tied to the course objectives and assignments encourage social interaction between students and the instructor. It is important that these interactions are meaningful by provoking critical thought of the concepts taught in class and how to apply them to answer the questions asked. Finally, the integration of a laboratory or recitation session provides another environment where students can apply their knowledge from the lecture sessions towards a different assignment. Whether groups are assigned or not, the participants of this study chose to interact with others more often within these environments than in lecture. Additionally, because students had more time to work freely on these assignments they were able to socially engage with one another in the way that best fit themselves. For example, Daniel's interaction with his laboratory partner in the computer science course was focused around their individual work, while James's interactions with his group members were centered on operating laboratory equipment and collecting data. Each student was able to engage at their own pace, which is structured differently than a lecture session.

A students' perceived difficulty of the course and assignments also influence their social engagement. Many of the participants of this study expressed how difficult assignments led to their interactions with the instructional team, their group members, other classmates in the course, and other professionals. Their perceived difficulty was reported in different forms, such as the amount of time they spent engaging with their peers, their cognitive exertion, or the attention to detail needed during their engagement. Throughout this study, as the participant's assignment became more difficult, the more often they would seek social interaction with others. One example of a participant's perceived difficulty came from Kacie's and her work with the geotechnical design in the capstone design course.

In the beginning of the capstone design course, Kacie was assigned to work on a real-world engineering project with three other students. Each student was responsible for developing the design of a single civil engineering discipline (structural, geotechnical, transportation, or water resource engineering), and together they were required to submit a group design report by the end of the twenty-week course. Kacie was responsible for the geotechnical engineering design for her group, while specifically focusing on soil slope reinforcement alternatives. She had never constructed an in depth engineering design to this point, so she regularly sought the help of her group members, the instructional team, and previous instructors within the civil and forestry engineering fields. By the eleventh week of the capstone design course, Kacie had begun designing the soil slope reinforcement for their group project. At this point she decided to follow the Federal Highway Administration (FHWA) design manual procedures because she had not designed a soil slope reinforcement system previously. The introductory steps included recommendations for soil size and type dependent upon the local water levels and superstructure, which Kacie recalled learning from other courses previously. In the later steps of the FHWA design procedures freeze thaw and other elements of the geotechnical design were mentioned that Kacie had not seen or used before, which she described as confusing terms. As she was following the FHWA design manual she had also been creating a Microsoft Excel table to organize all of the known information she had regarding the existing soil conditions, while leaving blanks for information on the freeze thaw. Because Kacie ran into difficulty, she planned

to meet with a roadway instructor that she had taken a course from previously so that she could receive clarification on the freeze thaw concept and get feedback on her design thus far.

Later in the week Kacie and her roadway instructor met in their office to discuss the work Kacie had done. Kacie expressed how she ran into confusion with freeze thaw, as she did not know what to assume as a standard value or how to determine the realistic value based on their existing site conditions. The instructor responded by defining how freeze thaw works, its relation to soil slope reinforcement, and why it is so important. Their discussion quickly shifted into talking about the design Kacie had been working on up to this point, which she described as a broad-based dip, and the other alternatives she and her group had considered. As a result of their discussion, her roadway instructor suggested multiple ways to go about designing a broad-based dip and coincidently had an old project that they had worked on previously and gave it to Kacie so that she could share it with her group members. Kacie estimated their conversation lasting one hour, and that the feedback she was given both verbally and with the engineering drawings helped make significant progress on her design.

It was Kacie's perception of difficulty which led to her seeking interaction with a previous instructor who had knowledge of the concept. At first Kacie had no problem following the design procedures outlined by the FHWA design manual. It was only when she became unsure of her ability to accurately determine the depth of freeze thaw on her project site that she began to change the way she engaged. In the face of difficulty Kacie sought out her roadway instructor because she felt that they would be able to address her questions and provide meaningful suggestions that could be used to complete her soil slope reinforcement design. While it was not explicitly described, Kacie most likely chose this instructor over other individuals because of her positive interactions with this person previously and their knowledge on the subject. The social interaction between Kacie and her roadway professor was meaningful because Kacie was able to obtain meaningful feedback from a professional and walk away with a physical copy of an engineering design implementing a broad-based dip, which Kacie used to create her design.

Perceived difficulty was expressed in relation to the course or an assignment by all of the participants in this study. While not all of the participants sought social interaction with their classmates and instructional team members when faced with difficulty, they occurred more frequently than when the participants were not challenged. As a recommendation to instructors, the development of assignments and curricula that challenge students to exert physical and cognitive effort to learn, understand, and master the skills and concepts taught throughout the course will significantly increase the likelihood of student social engagement. To construct an adequate level of difficulty, the instructor may need to develop various assignments through multiple iterations and receiving feedback from their students. It is also important that the instructor takes into consideration the student's perception of difficulty as well as their own, due to the difference in background knowledge. Allocating ample time for students to complete difficult assignments will encourage them to seek help from their instructors and classmates, which provides more opportunities for students to learn and understand the skills and concepts taught throughout a course.

A student's access to knowledge contributes to the depth or meaning behind their social interactions with other classmates or their instructional team. Participants in this study who engaged with multiple forms of media (lecture presentations and notes, literature of engineering research and standards manuals, laboratory handouts and procedures, or laboratory equipment) interacted with their peers in more meaningful ways. Social interactions themselves are also considered as access to knowledge, because instructors provide a wealth of knowledge that is shared, or accessed, through verbal lecturing or discussions in or out of class. Taking for example Kacie's design work mentioned prior, the access to knowledge from the FHWA design manual encouraged the social interaction with her roadway instructor. From their interaction, Kacie was given a set of engineering drawings with using a broad-based dip, which provides Kacie with further access to knowledge. The verbal feedback Kacie received during her interaction also proved to be useful, because she felt relieved knowing how to continue her broad-based dip design and determine the depth of freeze thaw on her project site. Had she

chosen another individual to converse with, the result of their discussion and feedback would have been quite different.

Other participants in this study explained how they used the PowerPoint slides presented during lecture, their laboratory reports and handouts, and online quizzes to review their work alongside another classmate to study for midterm and final examinations. Using these different types of resources provide students greater access to knowledge, which facilitated their discussions with other classmates and contributed to their academic success in the course. Instructors who provide opportunities for students to access knowledge will likely encourage social engagement. For example, instructors who integrate relevant literature to supplement course and laboratory assignments, lecture presentations, and course subjects may create more meaningful discussions with students in class, and encourage social engagement outside of class. However, student interactions did not form from the access to knowledge alone in this study, and were linked to the structure of the course and the student's perceived difficulty. Thus, it is important that instructors provide student access to knowledge to facilitate meaningful discussions in class, and offer additional ways for students to socially engage with the concepts taught throughout the course.

Instructors themselves can encourage or discourage student social engagement in and outside of the classroom. Specifically, the instructor's expectations for the course, and the social norms established by the instructor are critical in facilitating social engagement. Both Carter and Kim's transportation engineering instructor established a series of expectations at the beginning of the course which encouraged their social interaction throughout the entirety of the course. For instance, their instructor asked for students to construct new laboratory groups each week with classmates that they had not worked with prior. Carter explained that this expectation was a great opportunity for him to network with other classmates, and that he would not have socially engaged in the same manner had he been able to choose his group members each week. Additionally, Carter and Kim's instructor chose to regularly posed questions to the students and chose one at random to answer. Both participants briefly mentioned that this method of engagement kept them focused on the PowerPoint lecture, as they were expected to remain

focused in class. This also encouraged further discussion when the chosen student answered the instructor's question, which were followed by the students' questions.

For two of the laboratory assignments, Carter and Kim were required to use JAMAR equipment to collect traffic volumes in the field. This equipment required specific software to upload the data collected onto a computer, which only the course instructor had access to in their private computer laboratory. Students were expected to schedule a time to meet with the instructor to gain access to the computer laboratory. While the interaction between the students and instructor did not last long, the instructor expected students to be responsible for their own data analysis, while simultaneously encouraging social interaction.

Other participant's instructors had similar expectations for their students, as each instructor teaches in their own unique way. Based on the findings of this study, instructors who established expectations with students that they will be working with one another often, and implemented assignments and in class activities promoting collaborative work, that social engagement between students and the instructional team would be encouraged. The expectations presented previously are a few examples of how instructors may encourage student social engagement by the establishment of instructor expectations.

In addition to instructor expectations and the implementation of collaborative work, the instructor should consider the classroom social norms when encouraging social engagement. Social norms are the social rules of engagement that influence how students engage in and out of the classroom. For instance, Daniel's social interactions during the lecture sessions differed significantly from the laboratory and recitation sessions because of social norms. In lecture, Daniel followed along with the instructor as they presented a PowerPoint presentation by noting the information which he thought would be applicable to his homework and laboratory assignments. The last ten minutes of class was allocated to student question and answering, where Daniel remained silent because of his prior knowledge and re-enrollment in the course. The social norms of the lecture session confined Daniel and his classmates' social engagement

until the last segment of class, which discouraged Daniel's social interaction with the instructor because his questions were frequently answered beforehand. Conversely, the laboratory and recitation sessions were facilitated by teaching assistants who were responsible for providing feedback on student work. As Daniel began his laboratory and recitation assignments each week, he was able to progress at his own pace, but also receive guidance from his laboratory partner, and the teaching assistant towards completing his assignments freely. Daniel explained that he would discuss with his laboratory partner at the beginning of each laboratory session about the most efficient way to code the program verbally. In the event that Daniel became confused or finished his work, he walked to the front of the classroom with his laptop to physically get his code checked off for credit by the teaching assistant. Daniel typically remained quiet as the teaching assistant reviewed his work, and only interacted in depth when clarification of code or a concept was needed. The freedom to collaborate with others and give or receive aid encouraged Daniel to socially engage more so in the laboratory and recitation sessions than during the lecture sessions.

The differences expressed in the previous examples with Daniel and his lecture, laboratory, and recitation sessions were similar to the social norms with other participant's courses. Lecture sessions were commonly described as the time where the instructor presented information via PowerPoint presentations. Many of the participant's courses allowed students to ask questions as the instructor lectured, which provides the opportunity for students to discuss as a class and understand the lecture material in more depth than they might not have otherwise. Laboratory and recitation sessions commonly shared similar social norms, where students were able to work at their own pace, both individually and as a group, to complete laboratory assignments or course projects.

However, social norms should also consider student learning and comfort. While providing opportunities for students to ask questions during lecture may encourage social engagement to an extent, instructors need to decide the depth and tone of their discussion. Many of the instructors described in this study addressed the participant's questions by elaborating on their answer. For

example, during the sixth week of James's course, he asked his instructor a clarifying question about a series of graphs displaying the stresses and strains of soil specimens. His instructor took the time to go back over the graphs, restating the key points for James, and how the laboratory equipment could generate similar graphs. James redrew the graphs again with additional notes pertaining to their discussion. As the instructor shifted back into their PowerPoint presentation, James was able to make sense of the information to follow. James also chose to ask his question during the lecture, instead of after class, because he felt comfortable asking questions when he was confused or needed clarification. Conversely, Mitchell described how he rarely spoke up in class discussions because he was embarrassed when he answered a question incorrectly. Mitchell felt this way because he did not want to waste time with incorrect answers, and the instructor would answer their own question if nobody chose to answer. While this difference in comfort is out of the instructor's control, it is important that they know that comfort does influence a student's social engagement.

Establishment of social norms centered on student involvement and comfort were found to be the most influential towards encouraging student social engagement with a course. Instructors who allow students to ask questions as they arise creates an opportunity for deeper understanding through social interaction between the instructor and the students. Taking the time to thoughtfully answer questions help build trust and comfort among students, which encourage them to ask more questions or speak out during class wide discussions. The students who participated in courses with laboratory and recitation sessions frequently described interacting with their classmates and the instructional team to complete laboratory or course projects. These sessions gave students time in class to work at their own pace, while the instructional team offered help on an as-need basis. Additionally, students collaborated via assigned laboratory or project groups, which encouraged social interactions between students and their classmates. Students who were able to work at their own pace more commonly engaged socially, as described by this study.

In summary, fostering engagement within a classroom is discussed as not only beneficial in motivating students to learn but also necessary for deep conceptual learning. Similarly, previous work on the impact of informal learning environments also encourage the use of activities and experiences that supports student interaction. In each case, the purpose of engaging students is to create the opportunity for transfer of knowledge and skills from one context to another. In engineering education, it is of utmost importance that students develop the ability to transfer learning of core concepts from one level to another. In engineering for example, courses tend to build on each other. As such, it is imperative that students are able to recall and apply knowledge gained from one course or context to the next. Therefore, the conclusions drawn from this study serve the educational community by providing evidence regarding how students engage within a particular context. With these findings, educators can begin to develop a course curriculum that corresponds with student learning. The importance of social engagement in a course, as discussed through this research, could be used to encourage and facilitate student learning and engagement through frequent interaction between students, their classmates, and the instructional team. Specifically, instructors who shift their course structure, assignment difficulty, access to knowledge, expectations, and classroom social norms may have the best opportunity to promote social engagement with their students.

2.7 Limitations

While this study was carefully prepared and executed, it is important to describe its limitations. By conducting qualitative semi-structured interviews with student participants, the researcher understood that they would be collecting self-reported experiences. This acts as a limitation because the information presented may lack verification. While it may not be completely prevented, the researcher trusted students to recall engagements from the best of their abilities while offering follow-up questioning to probe for more detail. Secondly, the inherent uniqueness of each case in this study raises the question of sample size. The researcher believed that the seven cases studied uncover many of the individual characteristics and contextual factors influencing student engagement, with additional cases providing a marginal contribution to that

already discovered. The findings from this study represent the student engagement of several civil engineering and computer science students within a single university. The researcher understood that the findings may not be generalized across higher education institutions, but was aimed at exploring the essence behind student engagement in and out of class.

2.8 Future Research

Through the recollection of these students' experiences in and out of class in this study, the researcher were able to describe and interpret the ways in which the students' engagements were influenced by individual characteristics and context of their experiences. However, this study has also generated more ideas that could be conducted in the future. The current study recollected students' engagements through a single ten-week term. A potential future study could follow students through multiple courses to further interpret the influences of individual characteristics and context on student engagement. Additionally, future work could widen its sample size to study the influences on student engagement across other demographics. Replication of this study contributes to a collective understanding to the influence of context on student engagement in and out of class, whether student engagements are analyzed over a single term, or their entire academic program. A final thought for future work is to study student engagement out of class in more depth. There is a lack of recent literature capturing the essence behind student engagement once students leave the classroom. The goal of this future work should strive towards understanding the essence of student engagement holistically.

2.9 Conclusion

The goal of understanding student engagement in and out of class has been a challenge, due to the uniqueness of each individual and context of engagement. Recent literature has attempted to answer these questions, many of which isolate the classroom environment from out of class engagement because of direct or overt observation methods. However, student engagement in class can be influenced by the engagements performed out of class and Vis versa. The gap in literature motivated this study to explore how and why student engagement occurs, along with the influence of individual characteristics and context on student engagement. Seven student

participants were regularly interviewed to share how they engaged throughout a single course. Specifically, students self-reported their engagement both in and out of class during a series of semi-structured interviews. Analysis of student engagement through qualitative coding allowed researcher to learn about the students' perspective of how they engaged, which helped shape the researchers' interpretations of those events. The researcher began to find that the essence of student engagement was influenced by both individual characteristics and a variety of contextual factors in and out of class.

As students began sharing their engagements with the researcher, it became apparent that in and out of class engagements differed dramatically. While in class, students primarily conformed to the course structure established by the instructor. This includes taking notes (verbatim and summarized), engaging through in-class discussions, and collaborating with peers to complete in-class activities (in lecture, laboratory, recitation, and exercise sessions). Outside of class student engagement varied based on individual characteristics (motivations, interest, prior knowledge, personality), requirements of course assignments (time to complete, difficulty), and social interaction (group interaction, network, social norms). Social engagements recalled by students both in and out of class provided richer detail, compared to those without social interaction, as many described the interconnectedness of behavioral, cognitive, emotional, and social engagements. Students talked about why they interacted with a specific individual or group, what was discussed, if they were doing anything along with interacting, and the result of their interaction, which led the researcher to the influential individual characteristics and contextual factors described prior.

Millions of students attend public and private academic institutions yearly. These students are all unique in their own ways, which include how and why they engage with each course in and out of class. While it may be infeasible to ask each student how and why they engaged, it is important to understand the student perspective of a course when it comes to improving student learning. This study is able to provide a deeper understanding of students by describing and

interpreting their engagements that could be utilized by academic institutions, departments, and course instructors to improve in and out of class learning for students.

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[35] J. Walther, N. W. Sochacka, and N. N. Kellam, “Quality in interpretive engineering education research: Reflections on an example study,” *J. Eng. Educ.*, vol. 102, no. 4, pp. 626–659, Oct. 2013.

[36] P. Bourdieu, “Outline of a Theory of Practice,” *Cambridge Stud. Soc. Anthropol.*, vol. 16, no. 16, p. 248, 1977.

Appendix A – Interview Protocol

Code:_____
Date of Interview:_____
Week and Term:_____

Possible Questions Within the Classroom

Could you please describe what happened in class [today, last session, last week]?

In-Class Lecture Sessions

Tell me more about the _____ [{specific day's} lecture].

Day of the Week	**Monday**	**Wednesday**
Note-taking and Synthesis of Lecture *How you documented the discussion/lecture from _____ (day).		
Conversations and Discussions *Document who was conversed with, what it was about, and what happened as a result (any notes or actions to follow up?)		

Code:_____
Date of Interview:_____
Week and Term:_____

In-Class Recitation Sessions:

Tell me more about the _____ [{specific day's} recitation].

Interaction	**Individual - Based**	**Team/Peer - Based**
Design or Individual Work *Designate what was being done (broken up by the interaction), the process, the goal(s), and what was completed. *Engagement and Interactions included Recitation Day: (M/F)	*Description:* *Description:*	*Description:* *Description:*
Conversations and Discussions (Requires Interaction) *Document who was conversed with, what it was about, and what happened as a result (any notes or actions to follow up?) *This is useful for when a team member asks the professor about their project during this time.*	*Description:* *Description:*	*Description:* *Description:*

Code:_____
Date of Interview:_____
Week and Term:_____

Possible Questions Outside of the Classroom

Tell me about the things you did outside of class [today, this week, since our last meeting] that relate to your coursework in this class.

Out-of-Class Experiences

Could you talk about your what you have done relating to CE418 this past week?

Notes, Readings, and Additional Resources *What are the types of resources you searched or investigated? What kinds of notes did you record? Describe the engagement present. Record Durations if able/applicable.	*Day:* *Note / Read / Addt'l* *Description:* *Day:* *Note / Read / Addt'l* *Description:*	*Day:* *Note / Read / Addt'l* *Description:* *Day:* *Note / Read / Addt'l* *Description:*
Design Report and other assignment(s) *Description *(Resources, interactions, methods for assignment completion)* *Record Durations.	*Day:* *Description:* *Day:* *Description:*	

Code:_____
Date of Interview:_____
Week and Term:_____

Engagement with the Capstone Design Project *Individual or collaborative. Meeting with team members goes in this section as well.	*Day:* *Description:* *Day:* *Description:*	*Day:* *Description:* *Day:* *Description:*

Code:_____
Date of Interview:_____
Week and Term:_____

Meeting or conversation with the Instructor/ TA/ Peer(s) *Participant engagement with the interaction, what was discussed, why that peer was important to have that interaction with. This is essentially some of what will be shown on the project logs.	*Day:* *Name* *Topic:* *Engagement:* *Day:* *Name* *Topic:* *Engagement:* *Day:* *Name* *Topic:* *Engagement:*	*Day:* *Name* *Topic:* *Engagement:* *Day:* *Name* *Topic:* *Engagement:* *Day:* *Name* *Topic:* *Engagement:*