Motivating Students in Game-Based Learning: The Importance of Instructor Teaching Practices

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ABSTRACT

Game-based learning—using games to achieve learning objectives—represents a promising and increasingly popular means of progressing engineering education's decades-long goal of bringing more evidence-based, active learning pedagogy into the classroom. However, if game-based learning is to proliferate as a pedagogy, research on game-based teaching is critical to provide practical recommendations for implementation, making the pedagogy more accessible to instructors. However, reviews of game-based literature reveal that little work exists in the game-based teaching space, and what work exists models high-level teaching practices and archetypal roles, which often fail to pinpoint specific practices game-based instructors can use to be successful. Moreover, reviews of game-based learning literature more generally suggest that research on how to improve student motivation in game-based learning settings—an important variable for learning and a longstanding argument for the value of games in education—are lacking in both quantity and theoretical soundness.

To redress these gaps, I conducted a primarily qualitative, multiple-case study of seven non-digital game-based learning activities in engineering with the goal of furthering game-based teaching research and providing practical recommendations to instructors when using games in their classrooms. Using the MUSIC Model of Motivation as a motivation framework and the Observation Protocol for Adaptive Learning as a framework for categorizing teaching practices, I interviewed instructors about how they expected their teaching practices to affect student motivation, and I interviewed these instructors' students about how they actually perceived their instructors' actions as affecting their motivation. By comparing instructor and student responses, I derived recommendations for game-based learning practice that are likely to have a high impact on student motivation, and condensed these recommendations into a four-phase framework of game-based teaching to bolster student motivation. I supplemented my interview data with observation data to construct detailed summaries of each case I studied.

The recommendations I offer in my framework can serve as useful resources for instructors seeking to foray into game-based teaching practices or improve their existing game activities, especially in engineering. Moreover, my study provides a model for investigating game-based teaching practices and motivation in game-based learning using established theoretical frameworks in natural classroom settings.

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GENERAL AUDIENCE ABSTRACT

Game-based learning—the use of games to achieve learning objectives—is a promising and increasingly popular way to introduce active learning into engineering classrooms, which is something engineering education as a field has been trying to achieve for decades. However, if game-based learning is to reach a wider audience of engineering instructors, research on the teaching practices instructors use in game-based learning classrooms is important, so that researchers can provide practical recommendations to instructors and make game-based learning less intimidating. However, little work has been done to study these teaching practices, and the work that exists tends to look at high-level trends across teaching practices, rather than offering specific pieces of advice. Moreover, research on how to improve student motivation in game-based learning settings is lacking, which is a problem because student motivation is important for learning and is one of the biggest theoretical benefits of using games in education.

To fill in some of these gaps, I conducted instructor and student interviews around seven non-digital game-based learning activities in engineering, with the goal of furthering game-based teaching research and providing practical recommendations to instructors considering or currently using games in their classrooms. Using an established framework of student motivation and an existing means of grouping teaching practices, I interviewed instructors about how they expected their teaching practices to affect student motivation, and I interviewed these instructors' students about how they actually perceived their instructors' actions as affecting their motivation. By comparing instructor and student responses, I came up with several recommendations for game-based learning practice that are likely to have a high impact on student motivation, and I produced a framework to serve as a visual aid to help instructors implement teaching practices that can bolster student motivation at any phase of a game-based learning activity. I also supplemented my interview data with observation data to provide readers with detailed summaries of each case I studied.

The recommendations I offer in my framework can serve as useful resources for instructors looking to implement game-based learning activities or improve their existing game-based learning activities, especially in engineering. Moreover, my study serves as a model for future researchers who want to qualitatively study game-based teaching practices or motivation in game-based learning using established frameworks.

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Chapter 1. Introduction

1.1. Background

Engineering education research over the past decade has emphasized the importance of transitioning from traditional pedagogy focused on effective transmission of knowledge to learner-centered pedagogy focused on activities that help students actively construct knowledge. An emphasis on learner-centered pedagogy was present in early calls from the National Academies and the American Society for Engineering Education to improve student preparation for the engineering workforce (Jamieson & Lohmann, 2009; The National Academy of Engineering, 2005), and it continues to resonate in contemporary literature advocating improvements in areas such as curricular design (Lord & Chen, 2014), student problem-solving ability (Jonassen, 2014), and student retention (Lichtenstein et al., 2014). However, despite mounting evidence of the importance of learner-centered pedagogy, engineering education practice continues to lag behind research, as implementation rates remain low (Borrego & Henderson, 2014). According to research on pedagogical change in engineering education, improvements to implementation rates require learner-centered teaching activities that not only have clear practice recommendations to begin the process of onboarding faculty (Borrego & Henderson, 2014), but that are also motivating enough to engage students in the learning process and overcome common student resistance to instructional change (Borrego et al., 2014).

Accordingly, game-based learning—a broad term referring to the use of games in education—represents one learner-centered pedagogy that may serve engineering education particularly well, as both early and contemporary models of game-based learning highlight the strength of games in fostering both student learning and student motivation (Garris et al., 2002; Whitton, 2014). Furthermore, according to a recent systematic review by Bodnar et al. (2016), published research on game-based learning in engineering education has grown steadily in the past 15 years. Growth in the use of games has been due in part to the efficacy scholars have noted in using games to achieve desirable pedagogical outcomes such as establishing authentic problem-solving environments (e.g., Coller, 2010; Coller & Shernoff, 2009) and promoting multidisciplinary engineering teamwork skills (e.g., Hadley, 2014). However, while increased publication rates imply increased interest among scholars, the proliferation of game-based learning among engineering education practitioners is hampered in part by the scope of current scholarship around game-based learning. Particularly, contemporary research prioritizes the design and assessment of games without regard to classroom practices, limiting scholars' ability to communicate effective classroom practice recommendations. My dissertation research begins to address this gap by studying how games situate within classroom contexts, broader pedagogical practices, and instructors' goals for student motivation in engineering education. My results inform preliminary practice recommendations for game-based teaching in engineering education and provide a model for future study of game-based pedagogy.

1.2. Introduction to Game-Based Learning

Game-based learning, defined most generally, is an umbrella term that encompasses the use of digital games and non-digital games (board/card or classroom games) to achieve defined learning outcomes (Plass et al., 2015). While the concept of game-based learning has existed perhaps as long as games themselves (Smith, 2010; Toppo, 2015; Whitton, 2014), the recent wave of interest in game-based learning spawned from several influential works asserting the potential of games to renovate learning practices in U.S. schools (e.g., Gee, 2003; Prensky, 2001) and accompanying calls for scholars to study how games can be designed to affect learning and motivation (e.g., Garris et al., 2002). These publications prioritized digital games over non-digital ones, and most research has followed suit.

Following the distribution of these early influential works, literature reviews have captured hundreds of publications on digital game-based learning (e.g., Abdul Jabbar & Felicia, 2015; Bodnar et al., 2016; Clark et al., 2016; Ke, 2009; Wouters et al., 2013), the majority of which have focused on confirming or disconfirming the effectiveness of games for learning (Ke, 2009). Scholars have recently critiqued this research focus on the effectiveness of individual games as being too narrow (Jong et al., 2013; Young et al., 2012), and research questions focused on how digital games for learning should be designed have begun to take root in contemporary literature (Clark et al., 2016; Mayer, 2014). This new research focusing on design of digital games for learning is a marked improvement over the more basic question of "do games work?"

However, this new path of research on the design of games for learning continues to assert the importance of digital games and discount the instructors who will ultimately use these games. Accordingly, game-based learning literature falls into a common trap of research in the more general field of instructional technology, in which technologies themselves are treated as paramount to learning, rather than the contexts of their adoption and use (Papert, 1987; Reiser, 2001). Ignoring context of use in in the study of instructional technology leads most instructional technologies to fade into obscurity as instructors opt for potentially less effective technologies that are easier to understand and use (Zhao et al., 2002). For game-based learning research, a lack of robust practice recommendations is exacerbated by an almost exclusive focus on digital games, neglecting contexts in which non-digital games may be more effective. For example, New York City's *Quest2Learn* school—which is often cited as one of the earliest successful, large-scale implementations of game-based learning in a U.S. public school—designed its curriculum using primarily non-digital games, as these games were more adaptable to different learning objectives (Toppo, 2015). Accordingly, I argue that for game-based learning research to be useful and robust for educational practitioners, it will need to consider non-digital games as well as digital ones, and will need to investigate games in ways that highlight the practices and contexts surrounding their use. One way to conduct such an investigation would be to focus on the role of student motivation in game-based teaching contexts.

1.3. Introduction to Student Motivation and the MUSIC Model

Student motivation is a rich field of inquiry in educational psychology literature. It consists of many theories and models, each meant to address motivation in different contexts and from different explanatory angles (Eccles & Wigfield, 2002). For example, expectancy-value theory was created to explain gender differences in children's math persistence based on their expectancies for success and their subjective valuation of math tasks (Wigfield & Eccles, 2000), while self-determination theory was created to explain the degree to which motivation to pursue an activity is intrinsic by examining how well that activity fulfills one's basic psychological needs for autonomy, competence, and relatedness (Deci & Ryan, 2000). While some game-based learning literature has borrowed from established educational psychology theories of motivation and models such as the ARCS Model of Motivational Design (e.g., Bai et al., 2012) and self-concept theory (e.g., Miller & Robertson, 2011), it is surprising that many game-based learning studies do not refer to the rich body of educational psychology literature on student motivation (Plass et al., 2015). A meta-analysis of games for learning by Wouters et al. (2013) revealed that nearly half the included studies created their own questionnaires to measure motivation or related constructs.

The use of a well-defined, appropriate framework is important to study a construct like motivation, whose literature does not have a high degree of consensus regarding how it should be studied (Borrego, 2007; Brown et al., 2014; Murphy & Alexander, 2000). Doing so allows each study to connect with relevant branches of literature and ultimately advance the study of motivation in productive directions (Borrego, 2007). For my research, I use the MUSIC Model of Motivation, which was created by looking across multiple theories of motivation to create a list of five constructs instructors can use as guiding principles to create, execute, and assess classroom activities that motivate students to learn (Jones, 2009). Its focus on the design and assessment of instructor-facilitated classroom activities makes it a good choice for studying student motivation in the context of game-based teaching practices. Furthermore, the conceptual basis of the MUSIC model—that the actions of instructors have been shown in the literature to influence student motivation to learn—reinforces the need to study game-based learning in the context of teaching.

1.4. Purpose of Study

My study contributes to knowledge about game-based teaching practices by examining how engineering instructors at multiple institutions execute game-based learning activities in the classroom to affect student motivation. The purpose of this multiple-case study, in which each instructor's classroom represents a case, is to understand how instructors' beliefs about student motivation affect how they implement game-based learning activities, and how these activities are actually received by students from a motivation perspective. Cases included non-digital game-based learning activities, where the instructor played an important role in defining and facilitating the activities.

Grounded in the MUSIC Model of Motivation, the overarching research question for my study is: **What is the role of student motivation in (1) instructor beliefs that influence their use of non-digital game-based teaching practices, and (2) student perceptions of these teaching practices?** The overarching question was answered by addressing the following sub-questions:

RQ1. In what ways do engineering instructors believe their game-based teaching practices will affect student motivation?

RQ2. From a motivation perspective, how are instructors' game-based teaching practices perceived by students?

RQ3. What similarities and differences exist between instructor beliefs about how their game-based teaching practices will affect student motivation, and student perceptions of game-based teaching practices?

I have answered these questions using a primarily qualitative, multiple-case study involving the collection of interview data from students and instructors. I supplemented the primary interview data with quantitative survey data, as well as qualitative observations of game-based learning activities. Particularly, I collected data for seven non-digital game-based learning cases, allowing me to capture several classroom contexts spanning multiple types of games.

1.5. Study Outcomes and Significance

I produced three direct outcomes from my study: (1) visualizations defining the expected and actual relationships between instructor practices and student motivation; (2) a narrative of each instructor participant profiling their class and describing their expectations for how their teaching practices affected student motivation, a summary of the observed class session, and student perceptions of how teaching practices affected student motivation; and (3) a framework of game-based teaching that suggests examples of game-based teaching practices that instructors can implement to bolster student motivation at different phases of game-based teaching, including game activity design, briefing, gameplay, and debriefing. Together, these outcomes contribute to game-based learning pedagogy in engineering education in at least two ways. First, they provide a contextualized analysis of game-based teaching practices, contributing to knowledge and allowing me to make informed recommendations for practice in the design and execution of game-based learning activities. Second, they offer an example of the application of a contemporary framework to study student motivation from both student and instructor perspectives, helping game-based learning literature better connect to the rich literature on student motivation. I elaborate on these contributions to research and practice in the following sections.

1.5.1. Contributions to Educational Research

My study contributes to knowledge around game-based learning and student motivation by providing a means to understand game-based teaching practices and how they affect students' motivation to learn. Research across several theories of motivation has demonstrated that instructor actions and decisions can have substantial effects on student motivation (Eccles, 2007; Hidi & Renninger, 2006). While my results apply most saliently to engineering, they serve as an example to contextually research the bidirectional relationship between student motivation and the design of game-based learning activities in any field using a well-established framework of motivation. For engineering disciplines, my results provide a baseline for future research into game-based teaching practices.

Moreover, my study contributes to motivation research by investigating student motivation in natural classroom settings. Most theories of motivation derive from the broader field of educational psychology, where experimentation in controlled settings is the most common approach to research. While cause-and-effect relationships are easier to demonstrate using experimentation, fewer studies have demonstrated how experimental findings are actualized in different classroom contexts. The MUSIC Model is an effective model for the study of motivation in natural classroom settings, as it was designed to translate motivation research into effective teaching practice (Jones, 2009). My research provides one such study of natural classroom settings, examining how the MUSIC Model applies in several higher education classrooms in the United States.

1.5.2. Contributions to Educational Practice

This research most directly affects the instructors who participated in my study and their students. Through participating, instructors had opportunities to reflect on how their pedagogical decisions are affected by their beliefs about student motivation, and these types of reflective practices may be new to some instructors. Furthermore, by sharing the results of research with participants, I anticipate they have gained a better understanding of how their teaching practices affect their students' motivation to learn, and in some cases I also provided recommendations on how they might alter their practices accordingly. Every participant that decides to alter his or her activities in accordance with motivation theory could improve the academic motivation of dozens of students each academic term.

Moreover, by providing recommendations for game-based teaching practice, my research has the potential to affect educational practice more broadly. Zhao et al. (2002) assert that when considering adoption of an instructional technology, educational stakeholders need to know not only that the technology has merit, but also how that technology can be integrated into educational environments. Given that the majority of game-based learning research continues to focus on proving or improving the educational merit of games, my research represents a step toward establishing how games can be integrated into classrooms. In engineering education in particular, Borrego and Henderson (2014) specify the practice-informing research is an important first step toward adopting new pedagogical practices. Borrego and Henderson (2014) also specify that adoption can be further enhanced by disseminating such research not only to instructors, but also to stakeholders that can provide instructors with dedicated support as they attempt new and unfamiliar teaching approaches.

1.6. Scope of Study

It should be noted that my study examined only student motivation as an outcome, and does not address measures of student learning directly. While student learning is the ultimate goal of game-based activities, student motivation is an important consideration in the learning process (as discussed further in Chapter 2), and student motivation is more immediately relevant to promote the adoption of game-based pedagogy by overcoming student resistance to change.

1.7. Summary

To summarize, there is a need for new directions in the study of game-based learning in engineering education because: (1) interest in game-based learning is increasing, but little literature exists that offers practical recommendations for the implementation of game-based learning activities; (2) motivation is heralded as an important outcome of game-based learning, but treatment of motivation in the literature is lacking in terms of use of motivation frameworks, and in terms of studying how instructor practices affect student motivation; and (3) non-digital games are often sidelined in the literature, despite being more useful than digital games in some educational contexts. Through my qualitative, multiple-case study, I used the MUSIC Model of Motivation to investigate the role of student motivation in the implementation of non-digital game-based learning activities, and in student perceptions of these activities. Study results enumerate many game-based teaching practices and their relationships to student motivation, and inform practices recommendations that can help engineering instructors improve or adopt game-based teaching practices.

Chapter 2. Review of Literature

2.1. Introduction

Expanding my arguments in Chapter 1, three issues are inherent to the need for my study. First, engineering education faces challenges in realizing pedagogical change, and practice-based literature rooted in student motivation can help overcome these challenges. Second, three limitations embedded in the foundations of contemporary game-based learning literature hinder the ability of researchers to inform game-based learning practice. Third, extant game-based learning studies point to a need to better utilize existing frameworks of student motivation, and I will accordingly present the MUSIC Model of Motivation as the conceptual framework of my dissertation.

2.2. Pedagogy in Engineering Education

In their seminal call to action for engineering education, *The Engineer of 2020*, The National Academy of Engineering (2005) outlined six principles to guide engineering education institutions to better prepare engineers for industry by the year 2020. Underlying several of these principles were recent advances in cognitive learning theory outlined by Bransford et al. (2000), who characterized learning as a process of connecting prior knowledge to new concepts in ways that require as much active participation from the student as from the instructor. Thus, The National Academy of Engineering (2005) proposed that engineering education should be revised such that instructors have both the disciplinary expertise needed to teach, as well as the pedagogical knowledge needed to guide students in actively developing expertise. They further emphasized that faculty must be considered as the most direct levers to instantiate these changes.

The National Academy's call was operationalized by Jamieson and Lohmann (2009) in their seminal work for the American Society of Engineering Education, which intended to provide further direction for change in engineering education. Particularly, Jamieson and Lohmann (2009) asserted the need for more learner-centered approaches to teaching—in which instructors play a scaffolding and facilitating role rather than an exclusively lecturing one—and proposed a model for how to close the gap between research on learning and teaching practice. Ongoing calls for improvement of pedagogy in engineering education can be found in several chapters of the recently published *Cambridge Handbook of Engineering Education Research* (Johri & Olds, 2014). For example, when discussing curriculum design in the sophomore and junior years of engineering education, Lord and Chen (2014) called for more small-group work, formative assessment practices, and contextualization of concepts. As another example, after discussing how engineering students learn how to solve problems, Jonassen (2014) asserted the need to engage in self-directed learning through working with real-world problems. As a final example, Lichtenstein et al. (2014) proposed that teaching approaches foregrounding the learner have the potential to improve retention of underrepresented groups in engineering. The takeaways from these publications in the *Cambridge Handbook of Engineering Education Research* point to a longstanding and continuing need to improve teaching practices in engineering education.

However, as the target year of 2020 approaches, several organizations continue to note a slow pace of change in engineering education pedagogy. The Higher Education Research Institute (HERI) (Hurtado et al., 2012) found that STEM disciplines, including engineering, used lecture far more extensively than non-STEM disciplines in higher education, pointing to a slower rate of adoption of learner-centered pedagogy. The National Research Council (2012) supported HERI's conclusion, noting that science and engineering faculty are the least likely faculty in higher education to adopt learner-centered teaching approaches, on average. Finally, The President's Council of Advisors on Science and Technology (2012) reported that most STEM faculty members continue to teach using the lecture methods with which they were taught in their engineering education, citing lack of exposure, incentives, and resources as possible reasons for lack of pedagogical change. These reports suggest that lack of pedagogical change in engineering education (and other STEM disciplines) remains, despite ongoing calls highlighting its importance. Matusovich et al. (2014) concluded that engineering faculty are an important lever to instantiate pedagogical change, and called for more practice-based research to facilitate the change process from a faculty perspective.

Moreover, Borrego and Henderson (2014) suggested that the slow rate of pedagogical change may be remedied by considering literature on change in higher education, and particularly the model of STEM pedagogical change proposed by Henderson et al. (2011). Using the model's findings, Borrego and Henderson (2014) assert that pedagogical change begins with dissemination of research on new pedagogies with clear recommendations to guide instructional practice, and is maintained through ongoing support structures such as faculty communities and supportive local leadership. In addition to these insights for overcoming institutional barriers, Borrego et al. (2014) acknowledged that overcoming student resistance to pedagogical change is another important consideration. They recommended that instructors can reduce student resistance by taking action to reduce student anxiety, help students understand the value of learner-centered teaching approaches, and improve students' beliefs in their ability to succeed. In these publications on pedagogical change, Borrego and her colleagues emphasize two important factors to consider when beginning to construct change toward new pedagogies: (1) dissemination of research with clear implications for implementation, and (2) student motivation to engage with the new teaching practices. These two factors play important roles in my dissertation research. Presently, the latter factor deserves greater elaboration.

2.2.1. Roles of Student Motivation in Engineering Education

According to Eccles and Wigfield (2002), student motivation is a rich field of study in educational psychology, consisting of a multitude of theories that each attempt to explain a particular aspect of motivation by relating it to other psychological constructs. However, as Jones (2009) pointed out in his model integrating multiple theories of motivation (the MUSIC Model of Motivation), certain core psychological constructs pervade many of the theories. While Borrego et al. (2014) did not explicitly reference theories of student motivation in their recommendations for reducing student resistance, their suggestions reflect many of the concepts pervading student motivation literature. For example, both expectancy-value theory (Wigfield & Eccles, 2000) and future time perspective theory (Simons et al., 2004) assert that one's motivation to engage in an activity is related to how useful one believes the activity to be for one's life or goals. Moreover, the self-efficacy construct (Bandura, 1997; Schunk & Pajares, 2005), self-determination theory (Deci & Ryan, 2000), and expectancy-value theory (Wigfield & Eccles, 2000) all highlight the importance of one's belief in one's ability to succeed in an activity to one's motivation to participate in that activity. These constructs—utility and ability beliefs—underpin the recommendations made by Borrego et al. (2014) to emphasize why learner-centered activities are beneficial and to help students build confidence in their capacity to succeed in the activities. Thus, I posit, student motivation plays a crucial role in alleviating student resistance to pedagogical change in engineering education.

Moreover, student motivation plays another important role in promoting student learning in engineering education. Contemporary cognitive learning theory, popularized by Bransford et al. (2000) and advocated by others in engineering education via learner-centered pedagogy (e.g., Jamieson & Lohmann, 2009; Jonassen, 2014; Lichtenstein et al., 2014; Lord & Chen, 2014), emphasizes the importance of students' active engagement in the learning process. Extending the arguments offered by Eccles and Wigfield (2002), student motivation is the drive to action that compels students to such engagement. The primacy of student motivation to active learning was also emphasized by Ambrose et al. (2010) in her pedagogical framework to operationalize cognitive learning theory. Thus, a focus on student motivation can not only aid researchers in understanding how to overcome student resistance to pedagogical change, but can also bolster the effectiveness of the learner-centered pedagogies at the center of that change.

2.3. Game-Based Learning

From the preceding argument, engineering education would benefit from pedagogy that is not only learner-centered, but also structured to support student motivation. Game-based learning (GBL)—a broad term referring to the use of games in education—represents one pedagogy that is particularly promising, as literature on GBL has highlighted its potential to promote both learning and student motivation. One particularly influential early model of GBL came from Garris et al. (2002), who characterized GBL as an input-process-output model in which game features triggered certain behavioral cycles to keep players engaged in the learning process through gameplay. They concluded the presentation of their model by asserting the importance of support for both learning and motivation when designing games around their model:

> *Learners are not passive blotters at which we toss information; nor are they active sponges that absorb all they experience unaided. We must temper our enthusiasm for the gaming approach with the knowledge that instructional games must be carefully constructed to provide both an engaging first-person experience as well as appropriate learner support. (Garris et al., 2002, p. 461)*

More recently, Whitton (2014) authored a book overviewing research on GBL, presenting multiple theories and perspectives on games as tools to support both learning and motivation. Regarding learning, she argued for games as enablers of active learning, as they provide players with meaningful problem-solving challenges, situate these challenges within authentic and immersive learning environments, and provide context for social interaction. Regarding motivation, she argued that while not all people are motivated to pursue gameplay, well-designed games are inherently motivational tools meant to keep players playing them. She reinforced her assertion by presenting research on how games function as engaging events, how games are designed to engender enjoyment, and how games keep players behaviorally engaged through reward mechanisms.

As these models and theories suggest, GBL can be an effective pedagogy in engineering education by providing an active learning environment that motivates students to engage in novel activities rather than resist them. Accordingly, my dissertation provides a foundation for practice-based research in GBL that can begin to accelerate understanding and adoption of GBL as a pedagogy. The remainder of this section will overview extant literature on game-based learning, focusing particularly on issues that inhibit effective communication between researchers and instructors. First, however, a more precise definition of "games" is warranted.

2.3.1. Defining "Games"

While the term "game-based learning" is generally accepted in the literature to encompass the use of digital or non-digital games to achieve learning outcomes (Plass et al., 2015), definitions of "games" have seen far less consensus (Garris et al., 2002). In their comprehensive reference book on game design theory, Salen and Zimmerman (2004) demonstrate that at least eight definitions have been proposed to describe games, most of which share a handful of common features such as including well-defined rules and goals, but diverge on other features such as level of realism, voluntary participation, and level of uncertainty. Salen and Zimmerman (2004) conducted an extensive analysis of these eight definitions, extracting their core features and whittling away those features that were either too narrow as to exclude certain subsets of existing games, or too broad as to include other forms of media. In doing so, they arrived at an integrated definition of games, featuring six elements:

1. A game is a **system**, consisting of multiple people and/or objects that interact within a particular environment.
2. A game has one or more **players** that interact with the game to experience play.
3. A game is **artificial**, containing at least one boundary that separates gameplay from real-world activity.
4. A game embodies the contest of powers through **conflict**. Conflict can take the form of between-player competition or the efforts of one or more players to overcome the game itself.
5. A game has **rules** that delimit what players can and cannot do, defining the structure of gameplay.

6. A game has a **quantifiable outcome**, such that either the player wins or loses, or the player receives numerical indications of performance quality.

While this definition is by no means agreed upon in the GBL literature, it is perhaps the most comprehensive, as it was constructed systematically from several works of scholarship. Thus, I elect to use it as the definition of games for my dissertation, and it will play a prominent role in defining the scope of my methods in Chapter 3.

2.3.2. The Rise of Game-Based Learning Research

Game-based learning as a topic of educational practice is not new. The history of non-digital games for learning predates the Common Era, as tabletop games were used to train officers in military strategy as early as the Roman Empire (Smith, 2010). In reviewing a brief history of games in education, Jong et al. (2013) noted that non-digital games became a topic of interest in contemporary education in the 1960's, when constructivist theories of learning—on which much of the learning theory popularized by Bransford et al. (2000) is based—emerged and encouraged learning through play. However, Jong et al. (2013) continued, much of the interest in non-digital games began to be supplanted by interest in digital games in the 1980's with the rising popularity of home computer games. Many of these early digital games came under fire by scholars as being "edutainment"—meaning behaviorist reward-and-punishment systems with shallow game design—which contradicted the goals of constructivist learning theories by foregoing deep learning opportunities in favor of reinforcement of correct behavior. With the development of more sophisticated computer technology in the late 1990's and 2000's, games allowing for deeper learning through role-play and simulation have substantially grown in popularity (Jong et al., 2013).

Throughout this 50-year timespan, bodies of literature on both digital and non-digital GBL were steadily built (Jong et al., 2013; Whitton, 2014). However, the current wave of GBL research, which began in the early 2000's, has largely rejected previously popular behaviorist models of research in favor of constructivist approaches that highlight the importance of learner motivation, learning in context, and fostering learning communities (Jong et al., 2013). This focus on constructivist approaches appears to stem from three highly cited, influential works that appeared at the dawn of the century. The first was authored by Prensky (2001), who proposed digital GBL as a solution to the boredom and lack of engagement digitally native students experienced in modern education, and explored how school systems may need to change to accommodate GBL. The second was the aforementioned model by Garris et al. (2002), who asserted both learning and motivation as central to the design and research of digital games for learning. The last, and perhaps most significant, was authored by Gee (2003), who enumerated 36 ways that digital games embody evidence-based effective learning principles. Gee went on to establish one of the first GBL graduate programs, and has been instrumental in promoting game-based learning as a contemporary topic of interest (Toppo, 2015).

While the current wave of GBL research is auspicious in terms of its alignment with contemporary learning theory, the strategies these three seminal publications employed to advocate for GBL share three limitations that continue to hinder the ability of researchers to inform GBL practice for instructors. First, all three works discuss digital games almost exclusively, backgrounding non-digital games despite their usefulness in many educational settings. Second, all three prioritize games and their design features as the most valuable components of GBL, relegating variables related to games' classroom implementation as secondary considerations. Third, while motivation is considered an important factor of GBL in these works, few of their arguments connect to the rich body of research on student motivation, complicating the transition from the kinds of motivation desirable for game engagement to the kinds of motivation desirable for instructors. These three issues have propagated into the current wave of GBL research these seminal works helped to create, and I will elaborate on each separately.

2.3.3. Backgrounding of Non-Digital Games

As digital GBL research has risen in popularity, non-digital GBL research has fallen by the wayside. In his brief history of serious games—i.e., games designed specifically for purposes beyond entertainment—Wilkinson (2016) argued that rise of interest in research on digital educational games since the 1980's has been accompanied by a commensurate decline in research interest in non-digital educational games. To corroborate Wilkinson's account, I conducted a cursory search of the National Science Foundation's database for grants awarded since the year 2000, and found that the number of projects funded related to digital GBL outnumbered those related to non-digital GBL by a factor of ten. The shift in focus from non-digital to digital games may have undesirable consequences for GBL practice, as digital and non-digital games represent two different forms of instructional technology, and thus will have different sets of advantages and disadvantages for instructors, each being more desirable than the other in particular contexts.

One particularly important advantage of non-digital games for GBL practice is well-argued by the Institute of Play, the organization that created New York City's *Quest2Learn* school, which is often cited as one of the earliest successful, large-scale implementations of GBL in a U.S. public school (Toppo, 2015). In their resource guide for GBL design and implementation, the Institute of Play (2014) notes that approximately 90% of the games used by *Quest2Learn* are non-digital, as non-digital games can be easily and cheaply adapted to cover a variety of learning outcomes across multiple courses. Digital games, they argue, are often designed to meet a small, targeted subset of learning objectives and are difficult and resource-intensive to adapt for other purposes. Thus, non-digital games may be preferable in situations where instructors wish to use GBL to cover a range of topics. Furthermore, they may aid the implementation of GBL by eliminating the need to search for digital games that match one's objectives. The latter point is of particular relevance to contemporary GBL practice, as no repositories currently exist that allow instructors to reliably search for digital games that correspond to higher education learning objectives (Young et al., 2012).

Non-digital games may also be advantageous for instructor training and support in GBL, as I discovered through a June 2016 personal communication with Ian Zang, a professional development specialist from the Carnegie Science Center who regularly introduces K-12 teachers to GBL. When asked about lessons he has learned from his years of experience, Zang emphasized that he avoids introducing teachers to digital games until they are comfortable with non-digital GBL. The reason, he continued, was that learning digital GBL involves learning both pedagogy and a new technology, the latter of which often necessitates an overwhelming degree of troubleshooting expertise or access to technology specialists. Thus, non-digital games can help ease instructors into GBL pedagogy without the added cognitive load of simultaneously learning a new digital technology and make GBL more accessible in situations where cost constraints preclude the availability of technology or technology specialists. This ease-of-use advantage, combined with the flexibility of non-digital games, demonstrates the value of continued research on non-digital GBL practice, which my dissertation intends to model.

2.3.4. The Problem of Media Comparison and Technocentricity

As discussed earlier in this chapter, in order for game-based learning to proliferate as a pedagogy, research with clear recommendations for implementation must first be disseminated to instructors. However, in the case of game-based learning, research has thus far largely failed to produce such recommendations, as studies tend to focus on proving or disproving the effectiveness of games without regard to how games are implemented in the classroom. Many of these studies prioritize mitigating the effects of individual instructors on results rather than accounting for the effects of instructor practices. For example, researchers have commonly developed standard procedures for instructors to follow during GBL activities (e.g., Kebritchi et al., 2010; Miller & Robertson, 2011; Parchman et al., 2000) or sought to minimize or eliminate instructor interaction with student participants (e.g., Moreno et al., 2001; Papastergiou, 2009; Ritterfeld et al., 2009). These approaches to reducing instructor involvement in GBL research reveals an underlying assumption that a game's effectiveness should lie squarely within the design of the game itself, and not how the game is implemented by instructors. Notably, ignoring factors surrounding GBL implementation is in direct conflict with much of the early literature on the value of GBL in contemporary education, whose authors assert that games and their features should be considered in relation to the educational systems in which they are embedded (e.g., Gee, 2003; Hays, 2005; Prensky, 2001).

In a qualitative meta-analysis of GBL, Ke (2009) found that out of 89 included studies, the vast majority (65) sought to evaluate the effectiveness of games for learning, while only 9 investigated how game-based pedagogy can be operationalized by instructors. The game-based pedagogy publications focused on how learning environments surrounding gameplay should be constructed, including how student teams should be organized (Anderson, 2005), the benefits of student competition vs. cooperation (Ke & Grabowski, 2007; Strommen, 1993), and the impact of instructor facilitation (Sandford et al., 2007).

Although Ke's review is now mildly outdated, the trends she observed appear to continue. A recent book reviewing evidence of game-based learning by Mayer (2014), which calls upon the field to produce more "evidence-based approaches" to research, proposed categories of research questions that all emphasized games themselves as the focal point of investigation. Other recent literature reviews revealed the same trend, themselves seeking to look across studies to determine whether or not GBL is effective as a pedagogy (e.g., Bodnar et al., 2016; McClarty et al., 2012; Wouters et al., 2013). Interestingly, many of these reviews called for the need to consider variables beyond the game itself, but it does not yet appear that these calls have been realized to a noticeable extent.

The tendency to foreground new technology when researching technology-enhanced pedagogy is not unique to games, but rather is indicative of trends in instructional technology research more generally. In presenting a comprehensive overview of the history of instructional technology, Reiser (2001) noted that with the introduction of any popular instructional technologies, researchers tended to focus on "media comparison" studies, which ask questions such as "Does the introduction of this technology result in better learning outcomes than traditional instruction?" As in the GBL-specific examples noted in the preceding paragraph, media comparison questions prioritize assessment of the effectiveness of the technology itself.

Papert (1987) refers to media comparison research as "technocentrism," or "a tendency to think of [technologies] as agents that act directly on thinking and learning...a tendency to reduce what are really the most important components of educational situations—people and cultures—to a secondary, facilitating role" (p. 23). In arguing for more practice-centered instructional technology research, Zhao et al. (2002) asserted that technocentrism reduces the capacity of researchers to offer recommendations on how to implement an instructional technology in the classroom. As a result, they argue, most instructional technologies are rejected by instructors in favor of technologies that are more easily understood or familiar, even if they may be demonstrably less effective for learning.

While technocentrism currently dominates the GBL research landscape, some researchers have begun to call for research on how instructors integrate, facilitate, and scaffold gameplay, highlighting classroom implementations rather than games themselves (Abdul Jabbar & Felicia, 2015; Jong et al., 2013; Kangas et al., 2016). As Kangas et al. (2016) recently captured, a handful of studies serve as the vanguard for game-based teaching research. For example, some high-level, theoretical models of GBL pedagogy have been assembled from effective pedagogical practices more generally—including the PCaRD (Play, Curricular activity, Reflection, Discussion) model from Foster (2012), and the Orientation-Creation-Play-Elaboration model from Kangas (2010)—and have been used as the basis for some GBL studies. Research empirically investigating teaching practices during GBL at a more granular level is rare. Hanghøj and Brund (2011) and Hanghøj (2013) found that GBL instructor facilitation during gameplay could be categorized into one of four roles: instruction, playmaking (communication of how the game works), guiding (scaffolding learning), and evaluating. Other instructor roles have been proposed for the design of playful learning spaces (Hyvönen, 2011; Kangas, 2010), but all share the common trait of focusing exclusively on instructor practices during play. Accordingly, Kangas et al. (2016) critiqued current game-based teaching literature for its narrow focus, and called for practice-focused GBL research to also encompass how instruction is designed around games. They constructed a quadripartite model of game-based teaching-related activities from the little literature that did describe classroom implementations. Their model is shown in Figure 1, as it plays a role my proposed data displays in Chapter 3.

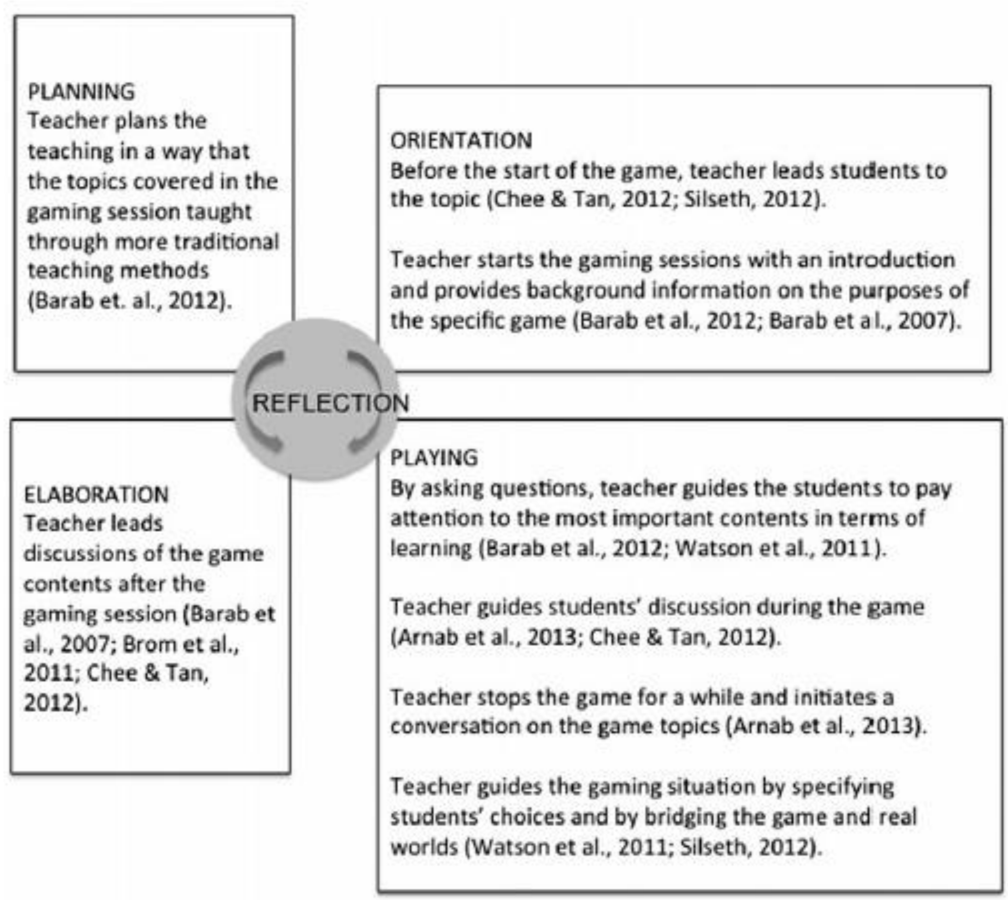

Figure 1: Model of game-based teaching activities by Kangas et al. (2016), used with permission from the publisher. Game-based teaching is presented as a four-phase, iterative process including planning, orientation, playing, and elaboration activities. Instructor reflection plays an important role across iterations.

Kangas et al. (2016) were not the first to propose such a model around game-based instruction. Two years prior, Alklind Taylor (2014) proposed a similar model through a multiple-case study of military and medical game-based training programs. This model—which she called the Coaching Cycle—also depicts game-based teaching as a four-phase model, with phases that correspond closely to those proposed by Kangas et al. (2016). The high-level similarities between these two independently developed models of game-based instruction suggest that, at least in the digital space, game-based teaching follows a fairly consistent overall structure. The Coaching Cycle can be found in Figure 2.

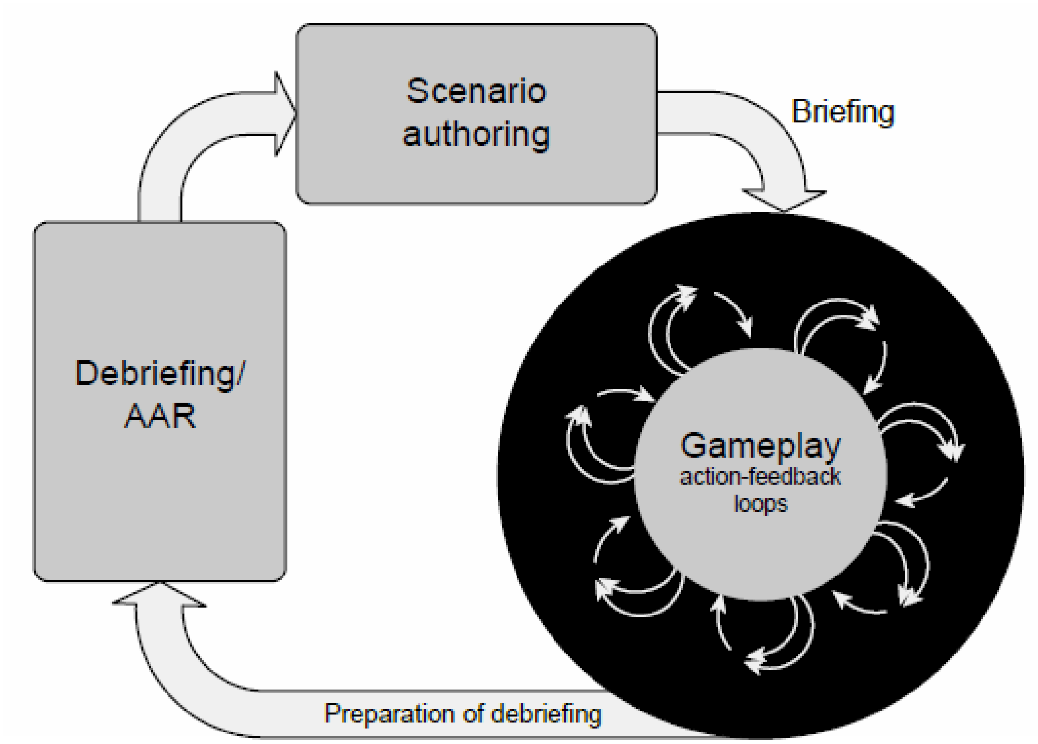

Figure 2: Game-based training Coaching Cycle model proposed by Alklind Taylor (2014), used with permission from the author. Game-based teaching is presented as a four-phase, iterative process including scenario authoring, briefing, gameplay, and debriefing.

Alklind Taylor (2014) references a number of other important trends in game-based teaching literature as well. Through several literature reviews, she suggested that briefing and debriefing processes have been discussed more commonly than teaching practices during gameplay, and game-based learning activities that are led by an instructor can have several benefits for learning processes. These benefits include increased instructor and student buy-in of game-based learning over time, boosted learner morale and rapport with the instructor during game activities, guidance for learners before they learn how to self-monitor learning and progress within a game activity, discouragement of "gamer" behaviors that are unproductive for learning, and increased transfer through reflective activities. Taken together, these potential benefits offer a strong case for the need to include instructors in game-based learning research.

Research on game-based teaching will be particularly important not only in providing clear recommendations for GBL implementation, but also in better understanding the motivation-related dimensions of GBL, as research has demonstrated that instructor interactions with students play an important role in affecting student motivation (Eccles, 2007). Moreover, teaching-focused research helps to advance learner-centered pedagogy by generating practice recommendations that can help instructors further their development as "guides on the side" (facilitators) during learner-centered activities. My dissertation is intended as an initial step toward the study of GBL as a pedagogical practice, particularly in examining the role student motivation plays in relation to instructors' teaching practices.

2.3.5. Treatment of Motivation as a Construct

As Eccles and Wigfield (2002) demonstrated in their review of motivation theories, the study of motivation is a field rich with a variety of ways to investigate the otherwise unobservable construct. Some theories seek to characterize the nature of motivation, such as intrinsic or extrinsic (Deci & Ryan, 2000); some strive to understand the underlying processes of what motivates an individual, such as in achievement goal theory (Elliot, 2005) or attribution theory (Weiner, 2000); and yet others aim to aggregate beliefs and values that have been strongly correlated to motivated behavior, such as in Eccles' expectancy-value theory (Wigfield & Eccles, 2000), the MUSIC Model of Motivation (Jones, 2009), or the self-efficacy construct (Schunk & Pajares, 2005). In the last category especially, theories and models of motivation are often careful to specify the types of motivation they address. Eccles' expectancy-value theory, for example, predicts a student's intentions to persist in a subject and his or her subsequent performance (Wigfield & Eccles, 2000), while the MUSIC Model addresses a student's motivation to put effort into learning activities (Jones, 2009).

While a handful of studies have successfully grounded the motivational foundations of GBL in established theories of motivation such as self-determination theory, interest theory, and achievement goal theory (Plass et al., 2015; Zusho et al., 2014), it is surprising that few empirical GBL studies have attempted to systematically connect to theories of motivation (Plass et al., 2015). For example, a meta-analysis of serious games for learning by Wouters et al. (2013) revealed that nearly half the included studies created their own questionnaires to measure motivation or engagement. These studies often failed to operationally separate motivation or engagement from related constructs. Motivation and engagement were often conflated with variable-quality operationalizations of situational interest (Kuo, 2007; Papastergiou, 2009; Ricci et al., 1996; Ritterfeld et al., 2009), entertainment or enjoyment (Papastergiou, 2009; van Dijik, 2010), intention to participate (Ricci et al., 1996), or vaguer constructs such as appeal or feelings (Brom et al., 2011; Wrzesien & Alcañiz Raya, 2010). According to Zusho et al. (2014), when game-based learning work is grounded in theory, self-determination theory (Deci & Ryan, 2000) is most commonly used, which is a theory that emphasizes psychological needs satisfaction of players in terms of autonomy, competence, and relatedness.

Furthermore, some researchers have elected to develop their own models and theories of what makes games engaging. Whitton (2014) discussed several models from game design literature regarding what motivates people to engage with games, including categorization of game activity preferences of online game players by Bartle (1996); an early model of intrinsic motivation to learn in games by Malone and Lepper (1987), which focuses on how well games inspire challenge, curiosity, sense of control, and fantasy; and several player engagement questionnaires that have emerged recently. Other more recent work has expanded upon this line of motivation research. For example, Tüzün (2006) pioneered a motivation framework to address predictors for prolonged engagement with games for learning in particular. While these approaches to studying motivation toward games are valuable in other research contexts, they are limited in applicability for instructional practice recommendations for two reasons. First, except in cases where instructors design and program the games they use, instructors have little control over the game elements featured in these models of motivation, and thus these models could only inform instructors' choices of which games to use in GBL. Second, numerous studies have emphasized the importance of building instruction around gameplay in GBL activities (e.g., Hays, 2005; Kangas et al., 2016), and models predicting student motivation to engage with gameplay alone will not be helpful in predicting student motivation toward other parts of GBL activities.

There are, of course, several GBL studies that were informed by relevant theories and models of student motivation. Of the studies included in Wouters et al. (2013) that did use a framework of student motivation, common frameworks included the ARCS Model, a motivation framework developed to inform the design of instruction (Keller, 1987), and self-concept, a construct addressing student perceptions of competence in a subject area (Bong & Skaalvik, 2003). Making these connections to educational psychology literature can help ensure that the type of motivation researchers are addressing is the type of motivation that instructors find valuable to their practice. My dissertation will connect to literature on student motivation by using the MUSIC Model of Motivation (Jones, 2009) as its conceptual framework, and the following section will expand upon the MUSIC Model and its relevance to the study of GBL practice.

2.4. The MUSIC® Model of Motivation

To summarize what I have discussed regarding student motivation so far, student motivation is a rich field in educational psychology. It consists of multiple theories to describe different aspects of motivation, rather than a single macro-theory that claims to explain all aspects of motivation. These theories vary in their purposes, including some that attempt to characterize the nature of motivation, some that try to understand the underlying processes of motivation, and some that aim to aggregate beliefs and values that are strongly correlated with motivated behavior. Most of these theories are careful to specify the kind of motivation they address, and none assert themselves as universally addressing student motivation. The framework of motivation for my dissertation will be the MUSIC Model of Motivation (henceforth simply called the MUSIC Model.) The MUSIC Model aggregates beliefs and values that other theories have correlated to student motivation, and the MUSIC Model particularly addresses student motivation to engage with learning activities, often simply called "motivation to learn."

2.4.1. Foundations of the MUSIC Model

The MUSIC Model was created by Brett Jones (2009, 2018), who asserted that student motivation to learn in a class can be explained through five empirically investigable variables, each derived from other theories of motivation in educational psychology literature, described below. For readers interested in a more comprehensive summary of theories that informed the MUSIC model, see Jones (2018).

(1) **eMpowerment** – The extent to which students believe they have meaningful control over their learning. This component derives from research on self-determination theory (Deci & Ryan, 2000), particularly on the importance of autonomy to intrinsic motivation (e.g., Reeve & Jang, 2006).

(2) **Usefulness** – The extent to which students believe the material will be useful to them. This component derives from literature on future time perspective theory (Simons et al., 2004) and the utility value construct of expectancy-value theory (Wigfield & Eccles, 2000).

(3) **Success** – The extent to which students believe that they can be successful if they put effort into a learning activity. This component derives from the extensive literature on ability beliefs, including self-efficacy and competence perceptions (Schunk & Pajares, 2005), as well as the expectancy for success component of expectancy-value theory (Wigfield & Eccles, 2000).

(4) **Interest** – The extent to which students find learning activities interesting and enjoyable, both in terms of short-term attention (situational interest) and long-term intrinsic engagement (individual interest). This component derives from the four-phase model of situational and individual interest developed by Hidi and Renninger (2006).

(5) **Caring** – The extent to which students believe the instructor cares about their success and well-being. This component derives from a variety of literature on the role of connectedness in motivation, including the "relatedness" component of self-determination theory (Deci & Ryan, 2000) and research on belongingness and caring (Baumeister & Leary, 1995; Noddings, 1992).

Jones (2009) created the MUSIC model based on the guiding principle that all five variables can be influenced by instructors, and the primary purpose of the model is to help instructors analyze and improve their teaching practices.

Since the MUSIC Model's original publication, it has been used in a variety of educational contexts, including engineering education. Researchers have used it to investigate student motivation in disciplinary engineering courses (Hall et al., 2013; Smith-Orr & Garnett, 2016), engineering student support programs (Hampton & Morelock, 2015; Lee et al., 2013; Lee et al., 2015), informal engineering learning environments (Akalin et al., 2013; Schnittka et al., 2012), and a senior capstone course (Jones et al., 2013). The MUSIC Model has also seen limited use in assessing student motivation in classrooms using games or game elements (Butler & Bodnar, 2017; Evans et al., 2014). The results of many of these publications have led to practice recommendations for teaching and learning environment design, and will be discussed after a brief justification of the MUSIC Model's appropriateness for my dissertation.

2.4.2. Appropriateness and Previous Applications of the MUSIC Model

I argue that the MUSIC Model is a strong fit for my dissertation study for four reasons. First, the MUSIC Model was constructed with the intention to help instructors analyze and improve their classroom practices (Jones, 2009). Thus, the model works well for my study, which examines the pedagogical practices of instructors using GBL through the lens of student motivation. Second, the MUSIC Model focuses on student motivation to learn, which is the type of motivation I intend to address. Third, the MUSIC Model has a history of use in engineering education research, which represents the primary body of literature in which I intend my dissertation to situate. Fourth, the MUSIC Model is cross-theoretical, and thus covers a wider range of factors that can influence motivation than most individual theories of motivation.

Previous applications of the MUSIC Model have demonstrated the significance of both instructional design and instructional practice in supporting student motivation. Although the MUSIC Model has seen limited application in GBL literature, research has reinforced the importance of studying the motivation-related impacts of the instructor as well as the game mechanics. In one study, Evans et al. (2014) used the MUSIC Model to assess a multi-phase project using the commercial digital game *Spore* to help teach evolution in U.S. biology classes. They found that game elements supporting student empowerment and providing opportunities for success were important to students' motivation, but also that the teacher's role in setting up caring environments that further supported student success was vital. In another study on the application of game elements to a learning management system—an example of a practice known as "gamification"—Butler and Bodnar (2017) discussed similar results. They found that the gamified system was important in empowering students to select interesting tasks to complete, but that responsibility fell upon the instructor to provide feedback to students that demonstrated caring and supported student success, and to explicate how the tasks students completed were useful for the course and for engineering work more generally.

The MUSIC Model has also been used to evaluate and inform teaching practice in many contexts outside GBL. I will specifically discuss how the MUSIC Model has been used in engineering education. Several of these studies serve to further reinforce the notion that the practices of instructors and other mentors are important influencers of student motivation. In redesigning an online nuclear engineering course based on the MUSIC Model, Hall et al. (2013) found that several particular teaching practices—including synchronous office hours, on-demand tutorial videos, and hints for difficult problems—were essential in helping students believe that they could be successful and in showing that the instructors cared. In explaining how different elements of problem-based learning in a senior capstone course affects students' motivation, Jones et al. (2013) determined that student interactions with faculty mentors were especially important to provide feedback supporting student success and empowerment, and to demonstrate caring. In examining student motivation resulting from participation in an engineering student support center, Lee et al. (2013) found that the actions of program administrators were important in several ways, including use of encouraging language to support student success and sense of empowerment, and one-on-one time with students to demonstrate caring. Notably, each of these publications (including those in the GBL literature) emphasize the role of instructors and other mentor figures in supporting the Success and Caring components of MUSIC more than the other components.

Moreover, engineering education studies using the MUSIC Model have demonstrated that instructor/administrator decisions in planning courses/programs also play an important role in influencing student motivation. Hall et al. (2013) found that the inclusion of social course elements such as a discussion forum in an engineering course helped support student success. Lee et al. (2013) found that different experiences designed into a student support center's programs affected each MUSIC component, such as proactive course help to support student success and leadership opportunities to engender student empowerment. Schnittka et al. (2012) designed an informal STEM learning program for middle school students based on the MUSIC Model, and found that student perceptions of the program were in line with their expectations of its benefits for student motivation. Inversely, Hampton and Morelock (2015) evaluated a summer bridge program chemistry course that was designed in absence of student motivation considerations, and found that several aspects of the course hindered students from developing interest or confidence to succeed in chemistry.

From these MUSIC Model applications, it is apparent that student motivation is influenced by decisions surrounding both instructor/mentor practices and design of courses and programs. The former speaks to a need to foreground teaching practices in the study of courses and activities intended to affect student motivation to learn. The latter speaks to a need to consider how instructors plan and design courses and activities with respect to student motivation. In order to do so, one must recognize that instructor beliefs about student motivation may not align with students' beliefs about motivation, which deserves further elaboration.

2.4.3. Instructor Beliefs about Student Motivation

In their book chapter on teacher beliefs, Turner et al. (2009) argue that rather than developing familiarity with literature on student learning and motivation, many teachers instead develop "common sense" knowledge of how learning and motivation work. They also assert that common sense knowledge is often inconsistent with findings in literature, and in some cases contrary to the literature. In terms of student motivation, teacher beliefs about what motivates students often contrast evidence about students' motivation-related beliefs. For example, in a study of high school students and teachers, Wiesman (2012) found that teachers tended to exaggerate the importance of their performance as a teacher (particularly in garnering student interest), while students overwhelmingly believed that they were most motivated when they were allowed to set meaningful goals and work toward them. Furthermore, in studying middle school teachers' self-efficacy in motivating and teaching students about engineering design problems, Van Haneghan et al. (2015) found that the majority of teachers did not think themselves capable of helping students develop intrinsic motivation. These two studies are part of a larger set of literature suggesting that instructors often consider use of activities that generate situational interest—i.e., temporary states of fun or enjoyment—as the extent of their ability to affect student motivation (Peterson et al., 2011).

Instructors' beliefs about student motivation may affect how they design and implement course activities (Turner et al., 2009). Thus, in my dissertation studying the role of student motivation in GBL instructors' pedagogy, it was important to not only consider how instructor practices affected student motivation, but also how instructor beliefs about student motivation affected their practices. Doing so helped further inform GBL practice recommendations by elucidating and addressing situations in which instructors' beliefs about student motivation misaligned with what motivated students based on the MUSIC Model.

2.5. Summary

Contemporary game-based learning (GBL) is a strong fit for engineering education as an emerging pedagogy, as it embodies the active learning theory advocated by calls for engineering education change (Gee, 2003; Whitton, 2014), and is commonly acclaimed to support student motivation to engage with GBL activities and thus can help overcome student resistance to pedagogical change (Garris et al., 2002; Tüzün, 2006; Whitton, 2014). However, while many studies have attempted to demonstrate the efficacy of GBL (e.g., Bodnar et al., 2016; Wouters et al., 2013), little is known about the teaching practices of instructors in GBL activities or how these practices affect student motivation. Thus, the scope of current knowledge around GBL limits the ability of researchers to offer informed recommendations for GBL practice.

In order to better connect GBL research with instructional practice and support GBL as a pedagogy, future research needs to address three limitations of the GBL literature. First, more research should highlight non-digital GBL, as non-digital games are advantageous to digital ones in many instructional contexts. Second, researchers should begin to transition toward research questions that situate games within instructional contexts, rather than focusing exclusively on games and their properties. Third, researchers should more adamantly connect to the rich literature on student motivation in educational psychology when investigating the role of student motivation in GBL. My dissertation is intended to serve as a step toward addressing these limitations by studying the role of student motivation in the implementation and outcomes of non-digital game-based teaching practices using the MUSIC Model of Motivation.

Chapter 3. Methods

3.1. Introduction

In order to investigate the connections between game-based teaching practices and student motivation, I conducted a qualitative, multiple-case study of how instructors use games in the classroom and how these practices affect motivation from a student perspective. The overarching research question for my study is: **What is the role of student motivation in (1) instructor beliefs that influence their use of non-digital game-based teaching practices, and (2) student perceptions of these teaching practices?** The overarching question was answered by addressing the following sub-questions:

- RQ1. In what ways do engineering instructors believe their game-based teaching practices will affect student motivation?
- RQ2. From a motivation perspective, how are instructors' game-based teaching practices perceived by students?
- RQ3. What similarities and differences exist between instructor beliefs about how their game-based teaching practices will affect student motivation, and student perceptions of game-based teaching practices?

The design of my study was guided by one methodological framework and one conceptual framework. Multiple-case study methods (Stake, 2005; Yin, 2003) represent the methodological framework for the study. The particular methods proposed in my study draw from multiple resources on case design, and aim to capture both repetition and variation by studying several non-digital game-based learning cases across multiple institutional settings, ensuring that cases are sufficiently different to yield interesting results while increasing the rigor of study by replicating cases within each type of institution.

The overarching conceptual framework for my study was the MUSIC Model of Motivation (Jones, 2009). Jones asserts that student motivation to learn in a class can be explained through five empirically investigable variables discussed more thoroughly in Chapter 2: (1) eMpowerment, (2) Usefulness, (3) Success, (4) Interest, and (5) Caring. Jones created the MUSIC Model under the pretense that all five variables can be influenced by the instructor, and the primary purpose of the model is to help instructors analyze and improve their teaching practices. Thus, the MUSIC Model represents a useful framework for the study of the motivation-related aspects of game-based teaching practices.

This chapter will discuss the details of the study design proposed to answer the preceding research questions. I will begin by discussing my philosophical perspectives and their contribution to the philosophical underpinnings of the study. I will then overview the research design with particular attention to how the cases will be bound. I will proceed to detail the proposed data collection and analysis procedures. I will conclude with a discussion of several other considerations, including bias, limitations, and IRB approval.

3.2. Philosophical Perspectives

In most matters of research, I am a pragmatist, which John Creswell defines as someone who is not tied to a particular epistemological philosophy, and who thus selects methods based on their suitability to answer the research questions, rather than on the basis of principle (Creswell, 2009). However, the study of teaching practices has been approached successfully from a variety of philosophies. For example, studies have attempted to use analyses from experts and students to identify effective and ineffective teaching practices with a semblance of objectivity (e.g., Southall & King, 1979; Varca & Pattison, 2001); to study instructors' mental models of teaching and learning as windows into their teaching practices and points of improvement (e.g., Haim et al., 2004; Manrique & Abchi, 2015); and to understand instructors' practices as functions of their contexts and experiences (e.g., Borko & Livingston, 1989; van den Haak et al., 2003). Therefore, as there appears to be no one means of studying teaching practices that is more useful than others, a more specific philosophical stance must be taken.

I have taken such a stance most closely resembling what Creswell (2009) calls social constructivism by anchoring my study primarily in self-reported interview data from students and instructors. Social constructivists believe that people make sense of the world as they interact with it, and that individuals' historical and social perspectives influence this sense-making process. By adopting a social constructivist stance, I am skeptical of the notion that there are objective links between specific teaching practices and student motivation, but rather that such links are subjective, and based on each participant's proclivities and experiences. Accordingly, in seeking to learn how teaching practices affect student motivation—both in terms of instructor expectations and student perceptions—I rely on participants' subjective accounts of salient teaching practices and their relationships to student experience, using less subjective data sources such as classroom observations primarily as a means to enrich my understanding and description cases and follow up on interviewee responses.

My study of student motivation, which inquires about the expectations instructors have for student motivation and about how students experience instructors' practices from a motivation perspective, also follows from a social constructivist perspective. However, one should note that the MUSIC Model was constructed by Brett Jones as an amalgamation of several other theories of motivation, all of which came from traditional cognitive psychology research (Jones, 2009). Thus, although I intend to use the MUSIC Model to guide research from a social constructivist perspective, the model itself gained validity from a postpositivist notion that motivation can be explained as cause-and-effect relationships captured by quantitative research (Creswell, 2009). Since its creation, the MUSIC Model has been adapted for interviews in non-postpositivist studies, as evidenced by Jones (2017) in his user guide presenting various ways the MUSIC Model has been used for research.

3.3. Research Design and Units of Analysis

Methodologically, my study is guided by multiple-case study methods, drawing particularly from the multiple-case design recommendations by Robert Yin (2003) and Robert Stake (1995, 2005). The *embedded multiple-case study* design proposed by Yin (2003) serves as the basis for my methods design. As the name of the design implies, multiple cases were studied in the form of different instructors in different classroom contexts. The term "embedded," according to Yin, indicates that each case involves multiple *units of analysis*, or entities being studied. In my study, each case features two units of analysis: instructors and students. The instructors in each case provide data on teaching plans and expectations for student motivation. Conversely, the students provide data on how they believed their instructors' actions affected their motivation. The overall case study design is represented in Figure 3, which is adapted from the suggested representation for embedded multiple-case study designs by Yin (2003). Although the term "replication" is used in the figure, in accordance with the language used by Yin (2003), the cases are not true replications in that they each use a different game. Rather, the term replication refers to multiple cases within the same kind of institutional setting.

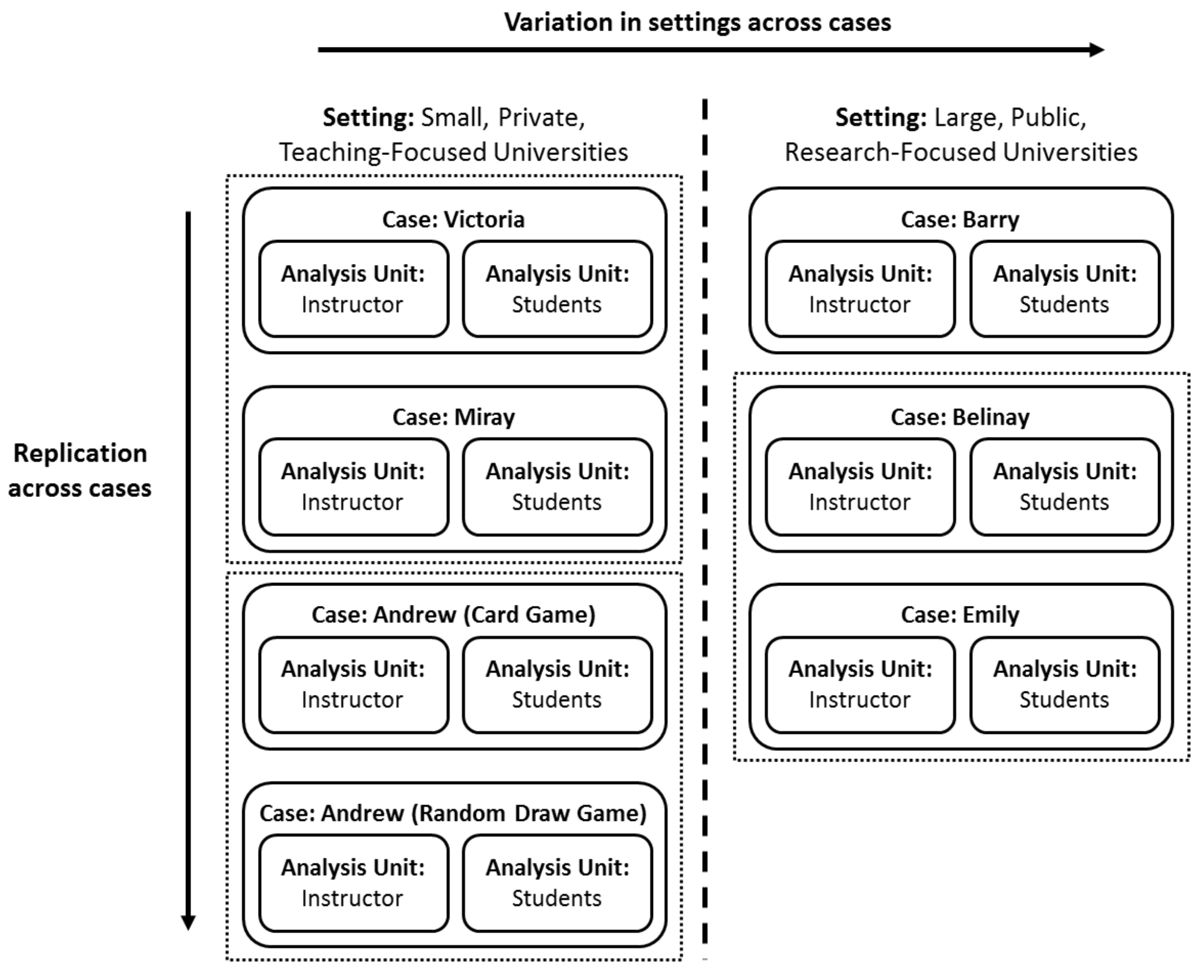

Figure 3: Overview of the multiple embedded case study design for my research. Institutional settings were determined via Carnegie Classifications. Cases in the same dotted square took place at the same university.

3.3.1. Bounding the Cases – Inclusion and Exclusion Criteria

Both Yin (2003) and Stake (1995) agree on the importance of establishing appropriate boundaries of what constitutes a case. In my study, the boundaries of a case are defined by two considerations: (1) the kinds of activities considered appropriate for study of game-based teaching, and (2) the number, duration, and location of activities considered appropriate for study within a given case. In addition to these considerations, all of my cases took place in engineering undergraduate classrooms at degree-granting institutions within the continental United States during the 2017-2018 academic year.

3.3.1.1. What counts as a non-digital game-based learning activity?

To define the kinds of activities considered appropriate for study of game-based teaching, I used the definition of "games" established by Salen and Zimmerman (2004). As elaborated in Chapter 2, my definition considers a game as having six essential characteristics: a game (1) is a system, (2) has one or more players, (3) is artificial, (4) contains conflict, (5) has rules, and (6) has a quantifiable outcome. Salen and Zimmerman's definition was constructed systematically from several works of scholarship, and I used its clearly delineated elements to determine if a given game-based activity should be defined as including a game, and thus should be considered a case in my study.

However, while Salen and Zimmerman's definition holds up well for games when compared to other forms of entertainment media, it could unintentionally encompass educational activities that are not game-based. For example, problem-based homework assignments common in engineering classrooms (Jonassen, 2014) could fulfill all the requirements of Salen and Zimmerman's definition. In these assignments, students ("players") work to solve problems (conflict) that are often simplifications of real-world scenarios (artificial), using concepts or techniques from a course (rules) to appropriately interrelate different parts of the problem (a system) in order to arrive at a numerical answer that will be graded for correctness (quantifiable outcome.) In order to avoid including these types of activities, an instructors' activities were only considered for inclusion as a case if (1) the activities meet the definition from Salen and Zimmerman, and (2) the instructor claims their activities to include games.

Finally, my focus on non-digital games did not exclude games that forayed into the digital space, most notably those of Victoria and Belinay, whose cases are detailed further in Appendix D. Victoria's game involved teams of students building and using a spreadsheet simulation to optimize a chemical process. When asked about whether she considered her game digital or non-digital, she stated that she considered it more akin to the non-digital space, as everything students were asked to do was doable by hand, but could be done much more quickly on a computer.

Belinay's game, on the other hand, was a digitization of a popular non-digital game called *The Beer Game*, which has been around for over half a century (Martinez-Moyano et al., 2005), and has been translated into many digital forms. The game involved students trying to manage a beer supply chain while being unable to communicate with others in the supply chain in any way other than placing orders. Belinay used an online version of *The Beer Game* that offered several affordances, including assigning students to supply chains anonymously, automatically producing graphs of supply chain performance, and providing the option of AI to act within supply chains in case of a student shortage—each supply chain requires four players. These affordances aside, the way students played fit well with how most contemporary versions of *the Beer Game* are played in non-digital settings (Martinez-Moyano et al., 2005), and I therefore considered it appropriate for my study.

3.3.1.2. Logistical considerations

The second consideration in bounding my study's cases is the number, duration, and location of game-based activities to be included in a case. Should a case be considered a single game-based activity or a collection of related game-based activities? Should activities (or collections of activities) that span multiple class periods be considered? Should activities conducted partially outside the classroom be considered? All of these questions are important to consider in bounding the cases.

Regarding the duration of activities, I only considered cases in which game-based activities can be observed in their entirety over one or two class periods, in recognition of the temporal and monetary costs of conducting observations across multiple days. Regarding location, I only considered cases in which game-based activities occurred entirely in class, as game-based teaching occurs in a much less direct form if the instructor is not present, and no observations of game-based teaching would be possible. Cases in which students prepared for the activity prior to class were acceptable, as were cases in which activities were conducted in multiple, self-contained modules, with one class session representing one module. However, cases in which a single activity was divided among multiple class sessions or conducted partly outside the classroom, such that students come into class to "pick up where they left off," were not considered appropriate for my study.

Regarding the number of game-based activities considered, all cases used only one game, but this outcome was a result of chance rather than case bounding. During the collection of pilot observation data from two instructors using non-digital game-based teaching—which are discussed later in this chapter—I decided otherwise. Both pilot class sessions involved more than one game-based activity, and both instructors tended to weave the activities together, either in building to a single message for the class session or in training students on how to reflect on the activities. In either case, processing a single game-based activity without consideration of the others conducted in the same class session would have resulted in an incomplete understanding of the game-based teaching situation. Therefore, if a case in which multiple game-based activities were conducted within a single class session had been included in my study, the class session itself would have represented the case.

There were several other considerations that could further narrow the scope of the cases, but I elected not to apply them as constraints. Classes were included as cases regardless of grade level, class size, engineering discipline, or duration of class sessions. Similarly, instructors were selected as participants regardless of their levels of teaching experience.

3.3.2. Collecting and Analyzing Case Study Data

While Yin (2003) and Stake (1995) agree on the importance of bounding cases, they disagree on the matters of data collection and analysis (Yazan, 2015). Both assert that the collection of multiple forms of data are necessary for a complete understanding of a case. However, Yin (2003) emphasizes the collection of both quantitative and qualitative data, while Stake (1995) focuses on qualitative data alone. Accordingly, Stake's data analysis strategies and methods for establishing rigor are informed by the qualitative tradition, while Yin's borrow from both quantitative and qualitative traditions. Because my study is designed primarily as qualitative research, my data collection and analysis methods (described in the next section) borrow more from Stake (1995) rather than Yin (2003).

My data collection and analysis procedures rely on two analytical frameworks. The first framework is the MUSIC Model for Academic Motivation, discussed at length at the end of my literature review. Table 1 displays my operationalized definition of each MUSIC component for my study.

Table 1: Operationalized definition of MUSIC Model a priori codes

MUSIC Code	**Definition – The coded teaching practice affected (or was expected by instructors to affect)...**
eMpowerment	...the extent to which students believed they had meaningful control over their learning or participation.
Usefulness	...the extent to which students believed the game activity will be useful to them. Does not include teaching practices that students found useful for gameplay (which would likely be coded with Success instead.)
Success	...the extent to which students believed that they can be successful if they put effort into the game.
Interest	...the extent to which students find learning activities interesting and enjoyable, both in terms of short-term attention and enjoyment (situational interest) and long-term, intrinsic engagement (individual interest.)
Caring	...the extent to which students believe the instructor cares about their learning, success, experience, and well-being.

The second framework is the Observation Protocol for Adaptive Learning (OPAL.) The OPAL protocol was established based on achievement goal theories of motivation by Patrick et al. (1997) for observations of adaptive learning activities, but is also a useful framework for the observation of other kinds of active learning activities, as it breaks activities down into nine categories that capture many important features of interest. Moreover, OPAL was designed to capture some aspects of activity design that might contribute to student motivation. I used the categories of OPAL to categorize teaching practices I found in my data. I broke up one of the original nine categories, task structure, to separate the task structure (design) of the game itself from the task structure (design) of activities that happened before and after the game, including preparatory student work, briefing processes, and debriefing processes. Counterintuitive to most game-based literature, game design is considered a teaching practice under the OPAL Framework, as the authors of OPAL posit that instructors have a great deal of control over the selection and design of active learning activities they conduct in their classrooms (Patrick et al., 1997). This resulted in ten categories of reaching practices, operationally defined and elaborated upon in Table 2.

Table 2: Operational definitions of OPAL categories used to categorize game-based teaching practices

OPAL Code	**Definition – Student motivation was affected by (or expected by instructors to be affected by)...**	**Includes...**
Task Structure: Structure of the Game	...the manner in which instructors structure tasks and learning activities. This code refers specifically to how the game itself is structured.	• The content, rules, gameplay systems, participation structures, and expected products of the game activity. • Materials and resources used during the game.
Task Structure: Structure before/after the Game	...the manner in which instructors structure tasks and learning activities. This code refers specifically to how the instructor structures activities leading up to the gameplay and activities following gameplay.	• Means of briefing and explaining the game to students prior to play. • Means of preparing the students for the game prior to play. • Means of debriefing and discussing the game following play. • Anything the instructor says about the reason for playing the game, its value, or its difficulty.
Authority	...the locus of responsibility in the classroom. This code refers to the flexibility of game rules, and how participants react to deviations from the rules.	• Anything the participant says about "breaking" the rules or taking action beyond what is explicitly allowed in the game rules. • Anything the participant says about the consequences or desirability of deviating from game rules.
Autonomy	...instances in which students can exercise meaningful choice (during or before/after the game.)	Instances in which students have control over... • The order in which they complete game tasks. • The content of their game tasks or pre-/post-game discussions. • The form of any products or outcomes. • When they complete game tasks. • How their work is evaluated. • Their level or nature of participation in activities during or before/after the game.

OPAL Code	Definition – Student motivation was affected by (or expected by instructors to be affected by)...	Includes...
Recognition & Feedback	...the standards, criteria, and methods that an instructor uses to recognize students in the classroom. In a game context, this includes recognition of "winners" and establishment of competition.	Public or private forms of recognition, including: • Prizes for doing well (praise, material prizes, bragging rights, etc.) • Means of recognizing progress (leaderboards, announcements, private comments, etc.)
Student Grouping	...the design and extent of grouping students for game activities and/or discussion, and of roles assigned within groups.	• The number and size of groups. • The method of group formation (e.g., random, students choose, algorithmic.) • Whether students have different roles in the group, and if so, how the roles are allocated and what they involve. • The characteristics of the groups (e.g., gender, ethnicity, intellectual diversity) • Support or behaviors as the result of being in a team (e.g., team enthusiasm, not wanting to let down one's team.)
Evaluation and Assessment	...the teacher's formal and informal assessments of their students' learning and behavior.	• Whether the game activity is graded or not, or other statements related to the stakes of doing well. • What the criteria for evaluation are. • Students evaluating their own work or their peers' work. • Reflection activities that occur around the game. • Instructors' informal assessments of student behavior or learning throughout the class (e.g., checking in on students, asking questions of students.)
Use of Time	...management of time during class, including schedules that guide activities, time limits on tasks, flexibility regarding both, and explicit statements that are made about time.	• If there is a set time schedule for class. • The extent to which time schedules are adhered to, and under what circumstances they are or are not. • Any comments made by the teacher or students about time restrictions. • How the teacher decides to progress the game.

OPAL Code	Definition – Student motivation was affected by (or expected by instructors to be affected by)...	Includes...
Help-Seeking Strategies and Responses	...behaviors and statements regarding students seeking help from the teacher, from other students, and from resources.	• What students do when they are unsure of what is required of them. • The manner in which students seek help from the teacher (e.g., publicly or privately.) • If students seek help from one another. • What the teacher says about getting help, and how the teacher responds to requests for help. • The resources are available for students to refer to independently.
Social Interactions	...student-student interactions and teacher-student interactions beyond those that occur as part of other OPAL categories (e.g., the task structure, modes of help-seeking, or summative/formative assessment.)	• Interactions that instructors have with groups and individuals beyond the brief/debrief and informal assessment practices • Student attributions of instructor interactions (e.g., friendly, approachable, funny, positive) • Anything the teacher says or implies about how students should interact with one another during activities • Student statements regarding a lack of instructor interaction.

3.4. Data Collection Procedures

Following recommendations provided by Stake (1995), data in my study included interview data and observation data. Data collection with instructors involved interviews before and after game-based teaching activities and researcher observations during the activities. Data collection with students involved individual interviews after game-based learning activities and a class-wide survey. Table 3 displays an overview of the data collection process, including the foci of the data and the research questions or products that the data were intended to address. The remainder of this section will introduce a small pilot study I conducted, discuss sampling procedures, and explicate the details of each data collection procedure.

Table 3: Overview of study data and relationships to research questions

Unit of Analysis	Data Collected	Foci of Data	Research Questions or Products Addressed
Instructors	Interview data prior to game-based activities	• Game description and background • Planned teaching practices • Expected effects on student motivation	RQ1, RQ3, Individual Case Summaries
	Observation data during game-based activities	• Instructor actions during activities	Individual Case Summaries
	Interview data following game-based activities	• Clarification of instructor actions and the reasoning behind them	Individual Case Summaries
Students	Interview data following game-based activities	• Student perceptions of the effects of game-based teaching on their motivation	RQ2, RQ3, Individual Case Summaries
	Class-wide MUSIC surveys on game-based activities	• Classwide perceptions of game-based activities with respect to each MUSIC component	Student interviewee bias analysis

3.4.1. Sampling Process and Case Descriptions

In qualitative research, participants are often purposively sampled based on specific criteria for inclusion (Krathwohl, 1998). In my study, cases were located by seeking undergraduate engineering instructors who presently used games in at least one class session of a course they taught. To my knowledge, there is no existing database of undergraduate engineering instructors who use games, and so alternative means were necessary to locate such instructors. Particularly, potential instructor participants were identified by reaching out to engineering professors who had published about their use of games in a journal or conference on or after 2014, and through snowball sampling via engineering instructors I knew who used games.

In order to control the scope of the multiple-case study, I sampled three instructors from large, public, research-focused universities and three instructors from small, private, teaching-focused institutions, one of whom volunteered to participate twice, leading to a total of seven cases. Although I reached out to several professors who published on their use of games, this outreach initiative met limited success, and all of the instructors who participated in my study were recruited through snowball sampling. In addition to recruiting instructors, I aimed to recruit four students from each case. I was able to reach this goal in four of the seven cases, but fell short on volunteers in the other three cases. Table 4 exhibits an overview of the seven cases along a few select characteristics; more detailed summaries of each case can be found in Appendix D.

Table 4: Select Case Characteristics

Case	Institution Type	Engineering Discipline	Academic Level	Class Size	Student Interviewees
Barry	Research	General	First Year	250	4
Emily	Research	Industrial	Senior	60	4
Belinay	Research	Industrial	Junior/Senior	25	3
Victoria	Teaching	Chemical	Junior	20	4
Miray	Teaching	General	Sophomore/Junior	10	4
Andrew (Card Game)	Teaching	Chemical	Senior	60	1
Andrew (Random Draw Game)	Teaching	Chemical	Senior	60	2

3.4.1.1. Game Descriptions

The seven cases featured six distinct games, with one game being used by both Barry and Andrew. Understanding the overarching structure of these games is important for interpreting participant quotes and results in later chapters. Therefore, even though these game descriptions are listed in Appendix D, I opt to describe the games in this chapter as well.

Barry. Barry's game was an engineering ethics card game, styled after the popular commercial games Apples to Apples, and its raunchier counterpart Cards Against Humanity. Barry designed the game alongside an educational researcher as a means of introducing engineering ethics topics to students in a fun and engaging way, and had used it once the previous academic year. In the game, one player acts as a "judge" and draws a prompt card from a deck of prompt cards. The prompt card contains a statement with one or more blanks that other players must fill in. For example a prompt card might read "It was a normal day on the job, until my boss started _________." The other players, who each have a hand of ten randomly drawn response cards from a separate deck, select card(s) from their hands to fill in the blanks. The prompt card is then read out loud by the judge, who fills in the blank with each submission. The judge selects a submitted card as the winner, based on any criteria he or she sees fit—the funniest cards or the cards that make the most sense in context are common criteria. That player gets a point, and a new player becomes the judge. This gameplay loop repeated until Barry announced the end of the game. Barry hoped that by playing the game, students would be exposed to novel engineering ethics-related scenarios and consider what they would do given the context of these scenarios, and that judges would think critically about why they picked certain cards as winners.

Andrew (Card Game). Andrew's card game was identical in structure to Barry's card game described above, as Andrew acquired the game from Barry. Andrew's goal in using the game was to get students engaging with ethics-related scenarios as an introduction to a larger module on engineering ethics, and also to provide an icebreaker activity for new student project groups.

Andrew (Random Draw Game). Andrew's random draw game was a random draw game meant to serve as an analogy for investing in preventative safety measures in chemical plants. Andrew obtained the game from a guest speaker who used the game as part of a larger chemical process safety module two years prior in Andrew's course. This was Andrew's second time running the game. In the game, teams of students drew beads randomly from a paper bag containing 100 beads. These beads represented events during a chemical plant's production. Most beads were green, signifying a successful round of production with no incidents, and earned the team a small profit. However, each bag contained a small amount of blue, yellow, and red beads, each signifying an incident with various levels of severity—ranging from a minor loss of profit to the plant exploding. Each bag was labeled and had a different distribution of beads known to the instructors but unknown to students. After each round, the team replaced the bead into the bag and drew again for the next round. During the game, students could purchase "protections" of each incident color, which negated the negative effects if a bead of that color was drawn, and was then discarded and could be purchased again. The goal of the game was to play 100 rounds (draw 100 beads) and still emerge with a positive profit and an unexploded plant. The game continued until all teams had played through (to a victory or loss) at least once. Andrew's goal for the game was to demonstrate the importance of process safety measures and give students an opportunity to practice safety-related decision making in a game setting.

Emily. Emily's game was a five-hour-long manufacturing simulation game in which teams of ten students formed a manufacturing "company" to plan and execute a production plan over a simulated nine-month period given a known distribution of random customer demand.

Emily discovered the game at an industrial engineering conference approximately 20 years ago, and decided to implement it as a capstone experience in her production planning course, helping students synthesize and apply the concepts and tools they learned throughout the course, while also giving them experience in working in large teams. She gradually adapted the game from its original form to fit her classroom context, and it has since become a permanent fixture in the course curriculum, even when Emily is not teaching it. This was Emily's thirteenth time implementing the game. The game's original form was published by Ammar and Wright (1999) under the title, ABC's Manufacturing Game.

Teams were formed semi-randomly, with students specifying other students with whom they wished to be on a team, and Emily assigning teams in such a way that each student was matched with at least one person they selected, where possible. In the game, each team was charged with working together to use an instructor-provided random distribution of customer demand—along with production planning and inventory management concepts learned throughout the production planning course—to construct and execute a complete production plan that maximizes profits based on customer demand and production costs. Students were given a three-week period in which to plan their production, during which they were provided a document describing how the game works, the anticipated customer demand distribution, and potential roadblocks they might encounter. Emily offered extra office hours during this time. A week before the game, students submitted their initial plans, and Emily provided each team with feedback prior to the game. During the game, six teams competed by executing their plans over a nine-period window during a single five-hour play session, with each period lasting an average of 20 minutes. In each period, students would order a certain number of parts—provided to them as slips of paper by the TAs—and would have to combine these parts in particular ways to create products that would hopefully meet but not exceed customer demand. Teams submitted their products to a TA (serving the role of the customer) who would verify they were properly constructed. Each period ended with a reveal of customer demand for each type of product, and the leaderboard of each team's profits—which was managed and verified by the TAs—was updated. Students then had to adjust their plans given the results of customer demand, along with other unforeseen events like workforce illness or defective parts. At the end of the game, students congregated around the leaderboard to find out who won. The game included a break midway with food catered by the hotel in which the game took place.

Each of the ten students in a team took a well-defined role within their "company," and was responsible for a particular part of planning or execution. For example, a student who took the role as a company's CFO was responsible for the majority of the financial planning process, while a student who took the role of a manufacturing worker was responsible for ensuring that parts were constructed during the game according to the company's ever-adapting plans.

The winner of the game received some points of extra credit on the final exam. Two weeks after the game was over, each team submitted a report reflecting on their results, experience, and lessons learned. This report was graded by Emily and comprised 20% of students' final grades.

Belinay. Belinay's game was a longstanding supply chain simulation game known as *The Beer Game*, which was developed at MIT during the late 50's and early 60's (Martinez-Moyano et al., 2005). Belinay learned about the game from her doctoral advisor, and has implemented it in her supply chain management course since she began teaching it several years ago. In the game, students are randomly assigned to teams of four, with each person representing a different actor in a beer supply chain—beer manufacturers supply beer distributors, who supply beer retailers, who ultimately supply beer retailers, who sell beer to simulated customers based on a simulated demand. The goal of the game is to maximize the profit of the supply chain across 35 periods. However, the catch is that students cannot communicate with one another through any means other than placing orders, true demand information is only available to the retailer role, and each order has a delay of one period to reach the next person up the supply chain, and two periods for the product to physically travel back down the supply chain. The game starts smoothly, with a steady customer demand of four beer cases per period. Then, a few periods into the game, that demand jumps to 8 cases per period. Retailers increase their orders accordingly, but get desperate as the orders don't come in three weeks as expected—as their suppliers also have delays further up the supply chain. The retailer then usually starts "panic ordering" by increasing their order quantity each period to overcompensate for their lack of inventory, and this panic ordering effect cascades all the way up the chain. By the end of the game, each student ended up with far more inventory they could possibly sell. This behavior is called the "bullwhip effect" in supply chain engineering, and is an intentional outcome of the game, as the purpose of the game is to demonstrate the importance of communication and collaboration across successful supply chains. In addition to learning first-hand about the bullwhip effect, Belinay hoped that students would recognize these takeaways through playing the game.

Belinay used an online, digital version of *The Beer Game*. How students interacted with the online game fit well with contemporary non-digital implementations of *The Beer Game* (Martinez-Moyano et al., 2005), with some additional affordances that helped move the game activity forward smoothly and quickly. These affordances included assigning students to supply chains anonymously to ensure communication among students was infeasible, automatically producing graphs of supply chain performance to inform the debriefing process, and providing the option of AI to take roles within some supply chains in case the number of students in the class was not evenly divisible by four.

Victoria. Victoria's game was a spreadsheet simulation game in which players attempted to optimize profit for a particular chemical reaction, where different reactor conditions and product purity yielded different costs and revenues. Victoria had been doing a similar spreadsheet simulation for eight years in her thermodynamics course, and decided to turn it into a competitive game four years ago. She conducted the activity as normal this year, but was uncertain how it would go, since her department had recently reorganized its curriculum and she was unsure what prior knowledge students were bringing from the new prerequisite courses.

Prior to the game, students independently prepared their own spreadsheets to automatically calculate the product of a specific chemical reaction (a water gas shift reaction) given the appropriate inputs (heat, pressure, moles of reactants, etc.) During the game, students were asked to modify these spreadsheets to incorporate the costs of different inputs and revenue from different product purities for the reaction, and use trial and error and optimize the reaction to maximize profit. Students were allowed to work alone or in self-selected groups. As students generated higher and higher profits, Victoria recorded the highest profits on a leaderboard projected at the front of the room. At the end of the game, the winner was awarded a plastic goblet with some chocolate in it. By using this game, Victoria hoped to introduce the idea that theoretically optimal conditions for a reaction often differ from optimal conditions to maximize profit in practice, which is an idea she expected students would explore in great depth during their senior design course the following year.

Miray. Miray's game was a cultural trading game meant to emulate the sensation of interacting with someone whose cultural norms are very different from one's own. It was an adaptation of the game BaFa' BaFa' created and marketed by the company Simulation Training Systems. Miray heard about the game from a colleague who asked her to help facilitate it in his class. She decided to use the game for the first time two years prior in her elective course on engineering communication, when she moved to her current university and observed it lack cultural diversity, with low international student representation. She has used it every year since, with this being her third implementation.

In the game, students were split evenly into two cultures and asked to play the roles of people in those cultures: (1) an alpha culture that was social, touchy, and proud, and (2) a beta culture that was reserved and desired personal space. The goal of the game was to conduct as many trades as possible with students in the other culture. Any classroom object or personal possession could be traded for a point, but only if the student interacted with the other culture in a way that the culture considered polite. The traded items were returned after the game. In the event of a successful trade, the student traded the object for a slip of paper that acted as currency to track scores. The catch was that what was considered polite in one culture was considered offense (and grounds for immediate trade rejection) for the other culture. Alphas only traded with students who touched their shoulder when presenting the trade, and betas loathed physical contact. Betas only traded with students who initiated a trade with the phrase "BaFa' BaFa'", which was an insult to one's family in the alpha culture. Each student had a worksheet describing their culture but knew nothing of the other culture. Therefore, students' goals were to figure out what to do to make a successful trade with the other culture. By using this game, Miray hopes to provide her students with an opportunity to reflect on the effort required to understand cultures very different from their own, and the mutual adaptation required for successful communication with that culture.

3.4.2. Data Collection with Instructors

My study's procedures for collecting data from instructors were modeled after a 1989 publication that investigated patterns of teaching planning and improvisation in K-12 mathematics education (Borko & Livingston, 1989). The researchers qualitatively studied the teaching plans, activities, and reflections of three novice math instructors and three expert math instructors. A pre-interview was used to elicit lesson plans for a one-hour class session, observation was used to study teaching behavior, and a post-interview was used to gather instructor reflections of the class session. The researchers analyzed the data with a particular interest in how novice and expert instructors handled instructional planning, execution, and differences between the two.

My study investigated game-based teaching practices using the same data collection process. First, instructors were interviewed prior to the conduct of game-based activities to elicit information about how their plans for conducting game-based activities were influenced by their expectations about how the activity would affect student motivation. These pre-interviews were the focus of my data analysis on instructor expectations of teaching practices that would affect student motivation. Second, instructors were observed conducting their activities, with particular attention to their specific teaching practices throughout each class session. Third, instructors were interviewed after the conduct of game-based activities to ask follow-up questions to clarify any unclear actions taken during observations, and to discern the reasoning behind actions where such reasoning was unclear. The observation and post-interview data were used to inform the individual case summaries in Appendix D.

3.4.2.1. Pre-Interview Procedure

The pre-interview protocol began with several broad, open-ended questions asking instructors to overview (1) their plans for implementing their game-based activities, and (2) why they chose to plan their activities in such a way, particularly with respect to anticipated effects on student motivation. The remainder of the interview's questions were adapted from an existing MUSIC Model interview protocol for instructors (Jones, 2017, p. 65). While Brett Jones initially created these questions to encourage instructor reflection on their own teaching practices, he has since encouraged their use in instructor interviews about their beliefs regarding their students' academic motivation (Jones, 2017). I adapted questions by changing their wording from present tense to future tense, and by altering the closed-ended nature of the questions to more open-ended questions about the game-based activity. For example, instead of asking "Do you feel that students have control over some aspects of their learning," I asked "What aspects of their learning do you feel students will have control over during the activity?" I piloted the interview protocol with a local engineering instructor based on one of the non-game-based, active learning activities she recently used in one of her graduate classes. The pilot interview revealed a need to inquire about the instructor's background with game-based learning and to inquire about their reasoning for their motivation-related responses. The final interview protocol for instructor pre-interviews can be found in Appendix A. Pre-interviews took approximately 60 minutes, and were audio-recorded and transcribed for analysis.

3.4.2.2. Observation Procedure

Observations occurred when I was in the classroom with the instructor during the activity. I piloted my observation process with two engineering instructors at different universities on their non-digital game-based teaching practices. Pilot data involved video-recorded observations of non-digital game-based learning activities during a single class session taught by each instructor, during which I took field notes, followed briefly by a set of follow-up questions to clarify questions that arose during observation. The pilot study allowed me to anticipate methodological pitfalls regarding my observations and adjust my data collection strategies appropriately. Particularly, I learned of the need to conduct post-interviews with instructors to clarify some of their observed actions. I also learned of the need to collect high-quality audio and video for later reference when writing case summaries, as game activities often move too quickly to capture with notes alone, and ambient noise can make hearing the instructor difficult through video recording alone.

Accordingly, during my study, I focused on obtaining high-quality video and audio recordings of the activity, as well as taking notes on interactions that may not be captured clearly in the recordings. I recorded the activity, with a particular focus on the instructor's actions, using a video recorder, and I requested that the instructors wear a wearable microphone for higher-quality audio recording. However, Andrew and Emily both declined to be audio recorded, leading to three cases with a heavy reliance on observation notes. Where applicable, video manipulation software (Shotcut) was used to combine and align the video and audio recordings. Observation data were used primarily to inform the case summaries in Appendix D, as described in the chapter when I discuss my data analysis procedures.

3.4.2.3. Post-Interview Procedure

The interviews conducted with instructors following the observations did not have a formal protocol attached to them. Rather, actions were noted during observations that were either (1) not clearly visible or audible to me, or (2) conducted with intentions that are unclear to me, especially where such actions deviated from the instructor's stated plans. The purpose of the post-interview was to ask clarifying questions about these actions, as well as questions about the classroom itself. For example, during pilot data collection, some follow-up questions included:

1. “You told students that there would be a 10 minute time limit to the game, but you let the activity last 20 minutes without saying anything. What was your reasoning for doing so?”
2. “I notice you were looking something up on your computer near the end of class. May I ask what you were looking up?”
3. “Do students typically participate this actively during discussions in class, or was this level of participation unique to the day’s activities?”

Post-interviews lasted 20 to 30 minutes, and were audio recorded and transcribed. They were used primarily to improve my understanding of my observations and thus informed the case summaries in Appendix D.

3.4.3. Data Collection with Students

The focus of student data collection was to determine how the activity, and the instructor’s actions in particular, influenced student motivation to learn based on the components of the MUSIC Model. Data collection took two forms: (1) individual interviews, and (2) a class-wide survey to serve as a point of comparison for interviewee beliefs.

3.4.3.1. Individual Student Interviews

I conducted individual interviews with up to four students per case, using an interview protocol adapted from the open-ended MUSIC Model questions for students provided by Jones (2017, p. 60). At present, the questions Jones suggests focus only on students’ perceptions of an activity in general, and not their perceptions of specific things the instructor does during the activity. Thus, adapting the interview protocol required adding questions that draw attention to the instructor. For example, the question “What made you feel successful during the activity?” was supplemented by the questions “What kinds of things did your professor do to help you feel successful in the activity?” I piloted this protocol with two graduate students based on the same active learning activity used to pilot the instructor pre-interview protocol. The pilot interviews revealed a need to jog students’ memories of the game-based activities they experienced and their takeaways from that experience, and to explicitly ask about individual interest as well as situational interest. The final protocol for student interviews can be found in Appendix B.

Interviews lasted 30 to 60 minutes. Participants were recruited on a voluntary basis via class-wide emails and in person at the end of class, and were offered minor compensation (a $10 Amazon gift card) for their participation. Where possible, interviews were conducted on the same day as the activity, following the class session. However, in some cases, interviews needed to be conducted as late as a week after the corresponding game activity. All interview sessions were audio-recorded and transcribed for analysis.

3.4.3.2. Class-Wide Student Survey

I also conducted a voluntary classwide survey that was sent out to all students prior to the observed class session(s), and that students in almost all cases—excepting Barry and Belinay—had time to fill out near the end of class. Barry and Belinay's students were asked by their instructors to consider filling out the survey outside of class. The survey was an adaptation of an existing, 26-item MUSIC Model instrument (Jones, 2017, p. 9), and can be found in Appendix C. It took approximately 5 minutes to complete. Students had the option of remaining anonymous, but were offered the chance of receiving a $10 Amazon gift card if they entered their email address. These email addresses were used to identify the survey results of student interviewees where possible, so that their scores on each MUSIC component could be compared to the class average.

3.5. Data Analysis Procedures

The outcomes of my study took three forms. The first outcome was a series of visualizations defining the expected and actual relationships between instructor practices and student motivation, which form the foundation for my Results chapter. The second outcome was a summary of each case describing each game and observed class, as well as comparing students' motivation-related perceptions to instructor expectations for student motivation; these summaries are found in Appendix D. The third outcome—the ultimate product of my discussion chapter—was a framework of recommended practices to bolster student motivation across all phases of game-based teaching, including game selection and design, briefing, gameplay facilitation, and debriefing.

The remainder of this section will discuss the data analysis procedures that were used to analyze data in a way that informed these outcomes. First, I conducted a student interviewee bias analysis to determine whether my interviewee samples were reasonably representative of the student populations from which they came. Second, and most critical for answering my research questions, I conducted data classification (coding and categorization) for instructor pre-interviews and student interviews to determine how teaching practices were expected and perceived to affect student motivation from both perspectives. Third, I used observation data—

supplemented by interview data—to craft summaries of each case in terms of the games that were used and the instructor's role in the observed classes. I end by discussing measures I took to ensure the integrity of my research.

3.5.1. Student Interviewee Bias Analysis Using Survey Data

Student interviewee bias was determined by comparing MUSIC scores of survey responses from interviewees—where available—to a 51% tolerance interval about the mean at 95% confidence based on the full survey sample. Based on the definition of tolerance intervals (Krishnamoorthy & Mathew, 2009), a proper interpretation of this interval is that one can say with 95% confidence that 51% of population of all students taking the course (i.e., the majority of students in the course) would have scores contained within the corresponding tolerance interval for each MUSIC component. If a student interviewee fell outside this interval for a given MUSIC component, one can say with 95% confidence that they were in the minority of students in terms of their score for that MUSIC component. Note that because the survey had two layers of voluntariness to it—filling out the survey was optional, and providing identifying data was also optional—seven of the 22 student interviewees had no corresponding survey data.

Table 5 through Table 9 display the results of my bias analysis. They display the mean score for each MUSIC component, the 51% tolerance interval for that component, and the MUSIC component scores of each interviewee. Instances in which an interviewee's MUSIC score was outside the corresponding tolerance interval are denoted by orange shading, along with arrows bracketing the MUSIC score to indicate whether it was above or below the tolerance interval. I found that bias tended to balance out across cases: There were approximately as many instances in which students scored higher than the majority of their classmates as there were instances in which they scored lower than the majority of their classmates. Moreover, two thirds of the interviewees with survey data scored in line with the class as a whole on at least four of the five MUSIC components. Therefore, I believe my student interviewees reasonably represented the classes from which they came.

Table 5: Student interviewee bias results for Barry's case (n = 150)

	MUSIC Component Scores				
	M	**U**	**S**	**I**	**C**
Sample Mean	*5.08*	*3.91*	*5.16*	*4.84*	*4.99*
51% Tolerance Interval (95% Confidence)	*(4.62, 5.53)*	*(3.08, 4.75)*	*(4.67, 5.65)*	*(4.19, 5.85)*	*(4.50, 5.47)*
Student Interviewee 1	↓ 4.60 ↓	3.20	4.75	4.67	4.67
Student Interviewee 2	5.00	4.40	5.00	5.00	5.33
Student Interviewee 3	No data				
Student Interviewee 4	No data				

Table 6: Student interviewee bias results for Victoria's case (n = 20)

	MUSIC Component Scores				
	M	**U**	**S**	**I**	**C**
Sample Mean	*4.73*	*4.47*	*3.98*	*4.34*	*5.12*
51% Tolerance Interval (95% Confidence)	*(4.10, 5.36)*	*(3.66, 5.28)*	*(2.85, 5.10)*	*(3.42, 5.26)*	*(4.59, 5.64)*
Student Interviewee 1	5.00	5.20	3.75	4.17	5.00
Student Interviewee 2	4.60	5.00	4.00	4.67	5.50
Student Interviewee 3	4.80	↓ 2.80 ↓	↓ 2.00 ↓	↓ 3.00 ↓	5.33
Student Interviewee 4	No data				

Table 7: Student interviewee bias results for Belinay's case (n = 11)

	MUSIC Component Scores				
	M	**U**	**S**	**I**	**C**
Sample Mean	*5.07*	*4.96*	*4.82*	*5.33*	*5.26*
51% Tolerance Interval (95% Confidence)	*(4.33, 5.81)*	*(4.29, 5.64)*	*(4.19, 5.44)*	*(4.84, 5.82)*	*(4.67, 5.84)*
Student Interviewee 1	5.20	5.60	4.50	5.33	5.50
Student Interviewee 2	5.80	↑ 6.00 ↑	5.25	↑ 6.00 ↑	↑ 6.00 ↑
Student Interviewee 3	No data				

Table 8: Student interviewee bias results for Andrew's card game case (n = 60)

	MUSIC Component Scores				
	M	**U**	**S**	**I**	**C**
Sample Mean	*5.17*	*4.29*	*5.31*	*5.13*	*5.18*
51% Tolerance Interval (95% Confidence)	*(4.59, 5.74)*	*(3.38, 5.20)*	*(4.83, 5.80)*	*(4.41, 5.85)*	*(4.67, 5.69)*
Student Interviewee 1	4.60	5.00	↓ 4.50 ↓	5.33	5.17

Table 9: Student interviewee bias results for Andrew's random draw game case (n = 59)

	MUSIC Component Scores				
	M	**U**	**S**	**I**	**C**
Sample Mean	*4.80*	*4.68*	*4.85*	*4.84*	*5.21*
51% Tolerance Interval (95% Confidence)	*(4.15, 5.44)*	*(4.01, 5.35)*	*(4.13, 5.57)*	*(4.12, 5.56)*	*(4.73, 5.69)*
Student Interviewee 1	5.00	5.00	5.25	5.50	↑ 6.00 ↑
Student Interviewee 2	No data				

Table 10: Student interviewee bias results for Emily's case (n = 95)

	MUSIC Component Scores				
	M	**U**	**S**	**I**	**C**
Sample Mean	*4.91*	*4.83*	*4.96*	*5.21*	*5.66*
51% Tolerance Interval (95% Confidence)	*(4.38, 5.44)*	*(4.13, 5.52)*	*(4.42, 5.51)*	*(4.73, 5.70)*	*(5.35, 5.97)*
Student Interviewee 1	↑ 5.60 ↑	4.80	4.50	5.00	↑ 6.00 ↑
Student Interviewee 2	5.00	4.80	5.25	5.17	5.50
Student Interviewee 3	No data				
Student Interviewee 4	No data				

Table 11: Student interviewee bias results for Miray's case (n = 10)

	MUSIC Component Scores				
	M	**U**	**S**	**I**	**C**
Sample Mean	*4.52*	*4.52*	*3.95*	*4.68*	*5.12*
51% Tolerance Interval (95% Confidence)	*(3.72, 5.32)*	*(3.40, 5.64)*	*(3.38, 4.52)*	*(3.61, 5.76)*	*(4.35, 5.88)*
Student Interviewee 1	↑ 5.60 ↑	↑ 6.00 ↑	↑ 4.75 ↑	↑ 5.83 ↑	↑ 6.00 ↑
Student Interviewee 2	3.80	4.00	4.00	4.33	4.83
Student Interviewee 3	3.80	↓ 2.80 ↓	↓ 3.00 ↓	↓ 2.83 ↓	↓ 4.33 ↓
Student Interviewee 4	4.60	4.00	4.25	5.67	5.33

3.5.2. Data Classification Procedures

This section discusses data analysis for instructor pre-interviews and student interviews, which are the focus of my results and discussion. Observation and post-interview data were essential in constructing case summaries to communicate the context of my cases (Appendix D), but were not instrumental in answering my research questions. Instructor pre-interview data and student interview data were transcribed and loaded into a qualitative data analysis software (MaxQDA) for analysis.

Data classification, often called “coding,” is a fundamental means of analyzing qualitative data by reducing the vast amount of data obtained from interviews and observations to more manageable chunks of data that relate to a study’s research questions (Creswell, 2009; Robson, 2011). For my study, data classification was conducted using the first three steps of the generally useful “thematic coding” procedure described by Robson (2011). The last two steps of the procedure Robson describes were omitted because they deal with higher levels of data integration intended to construct unified meaning of a phenomenon across participants. The purpose of my study was to describe variation across participants rather than to integrate meaning around a phenomenon, and thus higher levels of integration were not appropriate.

The first step of thematic coding is data familiarization, in which the researcher becomes broadly familiar with the context and content of each case before diving more deeply into the data set (Robson, 2011). In my study, data familiarization occurred naturally over the course of conducting interviews and observations, as well as the process of summarizing each case, primarily through observation data.

The second step of thematic coding is generating initial codes from the data (Robson, 2011). These codes can be *open*, created ad hoc from the data itself, or *a priori*, based on theory (Robson, 2011; Rossman & Rallis, 2011). In my study, open codes were developed for game-based teaching strategies based on how instructors described their planned teaching practices, and on how students described the instructor’s teaching practices. During this step of the thematic coding process, I coded any factor related to the game activity that students or instructors cited to affect student motivation. During later analysis, as I grouped these factors into OPAL categories, those that fit within OPAL were considered teaching practices, and those that did not fit were considered non-teaching factors that were excluded from further analysis.

For student motivation, a priori codes were used to identify the MUSIC component that instructors or students discussed as being affected by a particular teaching practice—rather than the MUSIC component to the teaching practice most closely related. For example, the establishment of competition was a teaching practice most commonly cited by teachers and students alike. While competition itself is closely related to the MUSIC component of Success—it establishes a means of “winning” the game—instructors and students more often described competition as helping to hold student interest in the game, and in this case was coded with interest. It was only coded with Success when students or instructors described competition as making students feel more or less successful during the game—which did also happen.

The third step of thematic coding is the categorization of codes into themes (Robson, 2011)—or as I will call them henceforth, categories. Because MUSIC components were coded a priori, no further categorization was needed. Codes for game-based teaching strategies were grouped into categories based on the framework established in the Observation Protocol for Adaptive Learning (OPAL). Each coded teaching practice was categorized under a single OPAL category. In cases where a code appeared to span multiple categories, I selected the OPAL category whose definition most directly fit the code. For example, one of Emily's students said that his professor helped his team believe that they could succeed when she made reasonable accommodations for mistakes:

> *Sometimes our material for the products wouldn't come on time, so she [Emily] was like, "Don't worry, I'll give you guys an extra few minutes to get it, because it's not your fault."*

I coded the teaching practice here as "temporal accommodations during game," and determined this code could fit under both Use of Time and Help-Seeking Strategies and Responses. I ultimately selected Help-Seeking Strategies and Responses, as Emily's accommodation was a direct response to the student's team notifying her about their products not coming on time. In addition to categorizing each teaching practice under an OPAL category, I categorized each teaching practice as a positive or a negative effect on student motivation, or both, based on how instructors and students perceived it.

The fourth step of thematic coding would normally be the construction of a thematic network map, which aims to identify core commonalities and themes across the data set (Robson, 2011). Instead, I used MaxQDA software to interrelate the game-based teaching strategy codes to the MUSIC Model motivation categories. Particularly, I applied codes such that teaching practice codes were embedded within MUSIC Model codes, and thus the perceived or expected motivation-related effects from student or instructor perspectives (respectively) were easily linked to particular categories of teaching practices. The MaxQDA software then enumerated frequency with which each category of teaching practice was cited to affect each MUSIC component.

3.5.3. Case Summary Construction

To improve the transferability of my results, I constructed a summary of each case I studied so that readers can familiarize themselves with the games, teaching practices, and MUSIC-related findings of each case. Each summary starts with a table of relevant case characteristics that I derived from a mix of observation, instructor pre-interview data, and knowledge of the case site. I then describe the game used in each case in detail, focusing particularly on the rules of the game, which instructors typically explicated at the beginning of class, and also described during their pre-interviews. Where the game was derived from another source, I provide a reference to that source. I also describe, from the instructor pre-interview data, the instructor's intended takeaways the game.

I then detail the class(es) that I observed during each case, which was derived from observation data supplemented with post-interview data. I focus on the instructor's actions and detail each observation in three phases: (1) the briefing and other pre-game preparation, (2) instructor facilitation during gameplay, and (3) debriefing and other post-game activities. Finally, I used my MUSIC and OPAL codes to summarize the primary differences between student and instructor responses regarding how teaching practices were expected or perceived to affect each MUSIC component. The completed case summaries can be found in Appendix D.

3.5.4. Establishing Credibility, Dependability, and Transferability

Credibility, dependability, and transferability are the qualitative counterparts to quantitative internal validity, reliability, and generalizability, respectively (Leydens et al., 2004). Because qualitative research is intended to capture results that are valid within particular contexts, one cannot expect that qualitative research should be controlled, replicable, or generalizable to other contexts. Instead, it is important that qualitative researchers demonstrate that readers can trust their descriptions and conclusions (credibility), and that the researcher was consistent in applying data analysis procedures (dependability), and researchers should help readers decide whether or not results should transfer to their contexts (transferability) (Anfara et al., 2002; Leydens et al., 2004).

In order to establish credibility, dependability, and transferability, I used strategies outlined by (Anfara et al., 2002). To establish credibility, I utilize peer debriefing by sharing my methods with my doctoral advisor, along with my results and snippets of my data, to discern if my conclusions made sense. I also used member checks to share summaries of findings with participants to determine if my analysis adequately represents their contexts. Instructor participants for all seven cases responded, and all suggested only minor revision, such as clarifying a game rule or the instructor's decision-making process.

To establish dependability, I utilized peer examination by recruiting a researcher with similar interests to perform an intercoder reliability check on a sample of the data (2 instructor pre-interviews, 2 student interviews), using high-level codes (OPAL Categories and MUSIC Components.) In some cases of disagreement, my colleague was unfamiliar with key details of the game that changed his mind when I explained them. In other cases where my codes disagreed with those of my colleague, I revised my operational definitions of the affected codes until we both agreed on their application, and occasionally updated some of my code applications in a way that resulted in minor changes in my results—but did not affect my overall conclusions. Finally, with respect to transferability, case summaries are available in Appendix D for readers to review and determine if the contexts of my cases are similar enough to their own contexts such that my results might transfer.

3.6. Biases

A handful of biases that may have affected my results should be noted. Some of these biases stem from my personal history and perspectives, and must be explicated as part of good qualitative research design. Other biases come from my behavior during the execution of the study's methods.

3.6.1. Researcher Biases

In qualitative methods, the researcher is considered the primary instrument of research (Creswell, 2009). It is therefore important that qualitative researchers practice *reflexivity*, the act of consciously acknowledging one's biases and how they may align or conflict of participants' perspectives to affect results (Rossman & Rallis, 2011). I have personal bias deriving from at least four sources: (1) my experience as a gamer, (2) the perspective with which I have begun to associate in the game-based learning (GBL) community, (3) my own experiences with GBL classroom activity, and (4) my career goals. I will expand upon each source of bias, potential effects of my biases on the research design and results, on ways to address my personal biases.

My first source of bias comes from my lifelong experiences as a gamer. My father introduced me to video games at age 3, so I cannot remember a time when I did not associate gaming as a part of my identity. For most of my life, I have considered games not only as a form of entertainment, but as a means of learning and self-growth. By the time I reached the third grade, I was playing educational computer games at 5th-grade math and reading levels, allowing my admission into accelerated learning classes. In middle school, I attributed my ability to reason through math and science problems to the problem-solving experience I had gained in games like *The Incredible Machine* and *The Legend of Zelda*. Moreover, through all of these game-based learning experiences, I was learning through a means I felt intrinsically motivated to pursue. By the time I reached my undergraduate studies and discovered a seminal book by James Paul Gee (2007) relating aspects of good video games to aspects of good learning practices from research, it was no surprise to me that games had value for learning and education. In fact, it was the discovery of ongoing research into the educational value of games that drove me to pursue a doctoral degree.

My second source of bias is my association with the rising "ecological" perspective on GBL. Arising from the findings of Young et al. (2012), the ecological perspective to GBL asserts that the value of a game for learning cannot be evaluated in a vacuum; researchers must take into consideration the context in which the game is being used (Young et al., 2016). The ecological perspective rejects the quantitative approach to prove the objective value of a game for learning—the most popular approach to GBL research (Ke, 2009)—and proposes instead to discover the educational conditions that enable games to be valuable. Therefore, while I believe games to be valuable for student learning and motivation in educational contexts, I also believe the value of GBL to be a function of classroom variables other than just the game itself, and this perspective forms the backbone of my study's entire design.

The third source of bias comes from my experiences with the use of games in college classrooms. As an undergraduate student, I experienced a single non-digital game-based learning activity used in a production planning course to integrate several course concepts, including forecasting and inventory management, and this game was the same one used by Emily in my study. As a graduate student, I was part of a research study that used the commercial board game *Pandemic* to teach engineering teamwork. The game-based activity for the study involved the instructor providing a tutorial for the game and hosting a discussion and lecture on engineering teamwork after play. From these limited experiences, I developed preconceptions of how games are used in classrooms, which is the main reason I sought to collect pilot data to capture other ways they might be used.

The fourth source of bias stems from my career plans. I intend to be in a role that will allow me to help engineering instructors engage in active learning practices, including game-based learning. Therefore, I considered it important to use my doctoral studies to discover alternative ways to engage in game-based teaching in different classroom situations.

3.6.1.1. Effects of Researcher Biases

My exposure to particular ways of game-based teaching and my desire to seek out a variety of ways to engage in game-based teaching affected my selection of cases. Particularly, where feasible, I looked for cases that appeared to offer different game-based teaching practices from one another and from those ways I have already seen. Within case study research, having cases that are substantially different from one another produces more interesting results (Yin, 2003).

During data collection, my biases also affected how easily I was able to establish rapport with different groups of participants. In qualitative research, establishing rapport with participants is important for ongoing participant cooperation in observations and interviews, and it involved showing participants that I was empathetic to their perspectives (Patton, 2002). Establishing rapport was easiest where my perspectives align with those of participants, which occurred easily with instructor participants, whose choices to use games in their classrooms indicated some level of belief in the value of games in education. Likewise, I found it easy to empathize with the perspectives of those students who had experience gaming, as well as those who approved of the game-based activities. However, I needed to be more intentional about establishing rapport with those students unaccustomed to gaming or who thought that the game activities in which they participated were not valuable.

3.6.1.2. Addressing Researcher Biases

The process of reflecting on my biases represents one step toward addressing them. Reflexivity allowed me to anticipate and plan for potential effects of researcher biases on my study, and thus I acted to reduce those biases by “bracketing” them, or setting them aside for the purposes of analysis (Miles et al., 2014). Furthermore, the credibility and dependability strategies described in the Data Analysis section, including interrater reliability checks and member checking, helped ensure that my perspective was not the only one included when analyzing the data.

Finally, I took action to ensure that my perspective on the value of games for education—or my opinion on which teaching strategies may have been effective or ineffective for supporting student motivation—was not projected onto the words of my participants. To mitigate the impact of my beliefs, I intentionally sought out both positive and negative evidence for student motivation. During data collection, I ended each student interview by asking what they wish their instructor had done differently during the game-based activity. During data analysis, I actively sought both positive and negative statements about the value of the game-based activities with respect to student motivation.

3.6.2. Methodological Biases

Because I am the primary instrument of data collection for the study, my actions and behaviors may have introduced bias that affected the data I collected. During interviews, bias may have been introduced through the questions I asked (Patton, 2002). A piloted interview protocol helped ensure that question phrasing did not introduce bias. However, I recognized that if an interview ran out of time with some questions left unanswered, the questions I decided to skip near the end of the interview introduced some bias. To abate my bias, interview questions were prioritized prior to data collection, such that each interview was consistent in the bias resulting from rushed questioning.

Bias in interviews could also have been introduced by my reactions to participant's questions (Patton, 2002). For example, if I reacted with an approving statement after a participant praises some aspect of a game-based activity, the participant may have been more inclined to focus on positive aspects of the activity and focus less on negative aspects. To abate reactionary bias, I followed the recommendation of neutrality in responses by Patton (2002). Particularly, he asserts that researchers should try to build rapport by validating the importance of the participant and their perspectives, while ensuring that reactions to the content of participant responses are neither favorable nor disfavorable. For example, instead of responding to a participant's response with "good" or "I agree," I endeavored to respond with "okay" or "I understand."

Bias can also be introduced during observations through my presence in the classroom with a recording device, as I experienced during pilot data collection. During one pilot observation, the instructor introduced me to his students asked me to talk a little about myself and why I was there. He expressed clear support for my efforts, and the students welcomed me and appeared to act naturally. In the other pilot observation, the instructor did not mention my attendance, though most students had acknowledged my presence and the fact that I was video recording the class. Although I tried to remain unobtrusive throughout the class session, I saw several students glance at me, looking either confused or suspicious. I inferred that these students may have been apprehensive about the unexplained classroom recording, and thus may have acted differently than they would normally. Accordingly, I did my best to develop rapport with instructors prior to observation and to leverage this instructor rapport to develop rapport with students.

3.7. Limitations

At least eight limitations arise from the design of my study. The first limitation is the openness of case bounding. Although I have restricted which activities count as "game-based" and the number, duration, and location of activities considered, I have left open many other characteristics of the classroom and instructor. In some ways, openness in case scoping is a benefit. When similarities across cases arose, I was able to make confident statements about which aspects of game-based teaching and student motivation appeared to be consistent despite variables like engineering discipline and instructor experience, assuming that cases span multiple levels of these variables. On the other hand, when differences arose, I was unable to say how much those differences are influenced by those variables. Moreover, it should be noted that I have excluded game-based learning activities that span many class sessions, which reduces the ability of my findings to transfer to classrooms using longer game-based activities. Consequences of this limitation are partly abated by measures to increase the transferability of my findings, particularly my inclusion of the case summaries in Appendix D..

The second limitation was the fact that all of my participants were recruited through snowball sampling, meaning that many of my participants were like-minded in their game-based teaching work, with two of them even using the same game. Because of this approach, my study may exclude several alternative approaches to game-based teaching. Again, consequences of this limitation are partly abated by measures to increase the transferability of my findings, particularly my inclusion of the case summaries in Appendix D.

The third limitation was that my study includes only non-digital game-based learning activities, while most of the literature on game-based learning and teaching focuses on the digital space. While I believe that studying non-digital game-based learning applications is valuable, the comparability of my results to extant literature may be limited. This limitation is partially abated by the fact that my definition of a game—from Salen and Zimmerman (2004)—is applicable in both digital and non-digital contexts. To further address this limitation, my discussion chapter describes the transferability of my results to digital game-based teaching settings.

The fourth limitation was that although the inclusion of multiple institutional settings was instrumental in ensuring variation between cases, cases within each type of institutional setting used a wide variety of games, and thus were not true replications. Therefore, I could make few institutional comparisons, as any institutional differences could easily be conflated with individual differences due to the kinds of games being used. This limitation was especially true for instructor responses, as each instructor had different learning objectives, goals, and teaching styles. However, because of the reasonably sized pool of student participants across universities, I was able to draw a handful of institutional comparisons between student interview responses at research and teaching universities that were not apparently attributable to individual differences between cases.

The fifth limitation involved the use of a small subset of students from each case to make statements about student perceptions of motivation as a whole within those cases. The students I interviewed may not have had views representative of their classes as a whole. To address this limitation, I conducted the student bias analysis presented earlier in this chapter, and determined the student interviewees to be reasonable representatives of the classes from which they derived.

The sixth limitation results from the use of interviews to promote instructor reflection on how they plan game-based activities. On one hand, pedagogical reflection could benefit participants by providing an opportunity to reconsider and alter their practice. On the other hand, such reflection may not be likely to occur typically, thus reducing the authenticity of the natural setting in which the study was intended to take place. None of these limitations threatened my ability to answer the study's research questions, but rather restricted the scope of arguments I could make and the populations of people for whom my study might be useful.

The seventh limitation was taking participants at face-value regarding their interpretation of each MUSIC component and factors that affected each MUSIC component. For example, many participants discussed competition as affecting student perceptions of Interest by making the game more fun. Drawing from goal orientation theory (Elliot, 2005), one could posit that competition shifts student focus away from an intrinsically motivated desire to set and achieve goals, and toward an extrinsically motivated need to perform well and prove oneself—an effect more closely related to MUSIC's Success component and perhaps even detrimental from the perspective of its Interest component. However, while such an interpretation may be theoretically valid, my participants did not interpret competition in such a way, and my analysis takes participant statements at face value. Further probing may have revealed that competition may have been considered fun for reasons other than its own sake (e.g., winning a game might have been a fun experience), but such inferences could not be made based on the data I collected. I do not anticipate this limitation was a detriment to my conclusions, and explicate it primarily to assuage concerns about the classifications of some teaching practices that arise from other theoretical perspectives.

The eighth limitation involves my operationalization of the MUSIC Model, which was based on the model's original form in Jones (2009). Jones (2018) recently updated the model to further elaborate upon how the MUSIC components work through motivation to affect student engagement and performance outcomes, and more saliently, how student motivation to engage with other tasks may detract from their motivation to engage in classroom activities, irrespective of the effect of MUSIC components on student motivation. The absence of this cost/benefit component of the updated MUSIC Model was not particularly detrimental to my conclusions, but would have helped explain some of my data. For example, one student in Belinay's case specified that he thought Belinay did a good job motivating the class, but that he personally was not motivated to engage with the game because he had a test later that day for which he would rather have been studying. Instances like this example were few and far between, but were present in my data, and were not captured by my operationalization of the MUSIC Model.

3.8. Institutional Review Board Approval

Virginia Tech human subjects research approval through the Institutional Review Board (IRB) was obtained before any participants are contacted. The current IRB issued approval for my project is IRB 16-1021.

3.9. Summary

This chapter has outlined the qualitative, multiple-case study research of my dissertation study. I used interviews with instructors and students to investigate game-based teaching practices and how they support or fail to support student motivation, along with observations to familiarize myself with my cases and construct sufficiently detailed case summaries. Through thematic coding analysis, I produced results that indicated the effects of particular game-based teaching strategies on student motivation through components of the MUSIC Model.

Chapter 4. Results

The purpose of my study is to answer the overarching research question: **What is the role of student motivation in (1) instructor beliefs that influence their use of non-digital game-based teaching practices, and (2) student perceptions of these teaching practices?** Toward achieving this purpose, I set out to answer three individual research questions:

RQ1. In what ways do engineering instructors believe their game-based teaching practices will affect student motivation?

RQ2. From a motivation perspective, how are instructors' game-based teaching practices perceived by students?

RQ3. What similarities and differences exist between instructor beliefs about how their game-based teaching practices will affect student motivation, and student perceptions of game-based teaching practices?

Through analyzing instructor pre-interviews and student interviews, I have descriptively identified and categorized the teaching practices proposed by engineering instructors to affect student motivation in different ways (RQ1), and the teaching practices perceived by students to affect their motivation in different ways (RQ2.) Comparing the two yielded important and interesting similarities and differences in how students and instructors perceive teaching practices to affect student motivation (RQ3.) This chapter presents these results, focusing on trends across cases. I encourage readers interested in case-by-case descriptions and within-case analyses to consult the case summaries in Appendix D.

4.1. RQ1: Instructor expectations of teaching practices & student motivation

Instructor interviews revealed that instructors expect different OPAL categories of teaching practices to affect student motivation differently, depending which components MUSIC Model about which they were asked. For example, instructors expected that their briefing and debriefing processes (Task Structure before/after the Game) would have a greater impact on student perceptions of Usefulness and Success than it would impact student Interest. Recall that instructors were not asked about OPAL categories directly, but the interview protocol was structured according to the MUSIC model. Table 12 exhibits the number of instructors citing teaching practices in each OPAL category they expected to affect student perceptions of each MUSIC component, as discussed in my data classification procedures in Chapter 3. There were seven instructors in total. The remainder of this section will further dissect each OPAL category to qualitatively describe the nature of teaching practices cited to affect each MUSIC component.

Table 12: Number of instructors citing teaching practices in a given OPAL category as affecting student motivation via a given MUSIC component (n = 7)

	MUSIC Component				
OPAL Category	**M**	**U**	**S**	**I**	**C**
Task Structure of the Game	6	6	7	7	2
Task Structure before/after the Game		6	6	1	2
Authority					
Autonomy	6		1	1	
Recognition and Feedback			4	4	1
Student Grouping	3	2	3	1	
Evaluation and Assessment	2	3			
Use of Time			2		
Social Interactions		2		1	5
Help-Seeking Strategies and Responses			2		2

4.1.1. Instructors: Empowerment (M)

Instructors expected that the kinds of freedoms available to students throughout their game-based learning activities (**Autonomy**) and the restrictions placed on those freedoms by the game's rules (**Task Structure of the Game**) would have the greatest impacts on student perceptions of Empowerment. Student input into group selection processes (**Student Grouping**) and the fact that most games were not graded (**Evaluation and Assessment**) were also expected to play a less prominent role in affecting student perceptions of Empowerment.

Given that OPAL's Autonomy category is similar in definition to the MUSIC Model's Empowerment construct, it is unsurprising that teaching practices falling within the OPAL **Autonomy** category were most commonly discussed by instructors as expected to affect student perceptions of Empowerment. Among these teaching practices were several kinds of flexibility that instructors explicitly allowed during gameplay, including adaptation to changing game conditions, development of a strategic approach prior to play, employment of course concepts to achieve game goals, and creative contributions to post-game discussions. Students were autonomous in how they took advantage of these kinds of flexibility, but instructors wanted to ensure that students were aware of these opportunities. For example, Belinay described how she believed the story of her game—in which students managed different types of companies in a supply chain system—would help draw attention to opportunities for autonomy, particularly in terms of developing their own strategic approaches based on course concepts:

> *I think [the game's story] will help [engage students]. I think just giving them, saying, you are your own manager – you apply whatever you know to manage your own company.*

Also embedded within Autonomy were implicit opportunities for students to play freely within the game's ruleset, and to creatively innovate and adapt within that space. Although instructors did not call attention to these opportunities for students during class, many nonetheless considered the flexibility of a game's ruleset to be an important contributor to student Empowerment. As an example, Miray described how opportunities student adaptation implicit in her cross-cultural trading game were a key element of student autonomy:

> *I think the degree to which [students] decide to adapt during the game to the other culture...can vary greatly. Some students will choose not to adapt at all and others will completely try to adapt. ... And sometimes those choices are governed by the vagueness of the rules because I never really explicitly say whether or not you can adapt, I just say your objective is to trade.*

Conversely, although the game's rules provided guidance on the kinds of freedom available to students—such as by defining parameters that students could manipulate—they also placed restrictions on how students could interact with the game. Therefore, the **Task Structure of the Game** was the primary detractor of Empowerment from instructors' perspectives, primarily by including rules that restricted student freedom. For instance, Barry described how the straightforward rules of his game sculpted the extent of student empowerment:

> *The gameplay [has] a fairly prescribed rule set, so there's not a lot of opportunity to deviate outside of that. But...[students] have complete autonomy over what cards they play. So, they're dealt a hand and they have ten cards, whatever they choose to play as the most effective combination in their mind, with the prompt, is totally up to them. ... Within the rule set, they've got a lot of autonomy in choosing how the game develops.*

While most instructors acknowledged during interviews that the Task Structure of the Game detracted from student empowerment, few considered this detraction detrimental—they noted that their games still allowed students a substantial amount of choice during play.

A less commonly cited source of Empowerment from instructors' perspectives was the degree of choice and input available to students during the **Student Grouping** process, where some instructors allowed students to self-group or provide groupmate preferences. Another was **Evaluation and Assessment**, where two instructors noted in interviews that student participation was technically optional since no grades were attached to their games—though no instructor encouraged non-participation in class.

4.1.2. Instructors: Usefulness (U)

Instructors expected that both forms of **Task Structure** (the structure of the game itself, as well as the structure of activities before and after the game) would be major influencers of student perceptions of Usefulness. Opportunities for students to self-assess their takeaways from the game (**Evaluation and Assessment**), opportunities to practice working in teams (**Student Grouping**), and reflective instructor prompting (**Social Interactions**) during gameplay were also expected to affect student perceptions of Usefulness, but to a lesser extent.

From an instructor perspective, Task Structure (both of the game and before/after the game) was most influential for student perceptions of Usefulness. Regarding **Task Structure before/after the Game**, six instructors agreed that the debrief discussion or lecture was an important factor helping students perceive the game as useful to them. As an example, when Belinay was asked what students would find useful about the game, she described how she anticipated the post-game discussion would help students find the game useful to their future professional lives by connecting events that went wrong in their supply chains to similar real-world situations:

> *The bottom line of this game is that we want [students] to understand the cause and effect, what went wrong, and what should [they] do to remedy the situation. So, we are trying to get into this management insight. ... When we have [the] group discussion, there are lots of very interesting observations and discussions and brainstorming that really [keep] them thinking after the game.*

Moreover, a different set of six instructors believed the usefulness of the game to be self-evident in the **Task Structure of the Game**, and expressed that students would realize this usefulness through interacting with the game activity. They anticipated a variety of mechanics being perceived as useful, including those that mimicked reality and also those that related to academic work. For instance, when I asked Emily why she expected students would find her game useful, she asserted that her manufacturing simulation game's mimicry of realistic production planning environments would be many students' first exposure to such an environment:

> *So many of [my students] have never worked in a manufacturing plant. And so this will be really close to realistic in terms of the types of decisions that are made in a manufacturing facility, and even how they are executed.*

A less commonly cited category of teaching practices was **Evaluation and Assessment**, where three instructors believed that structured reflection activities would help students self-assess their takeaways from the game, helping each student determine what about the game was useful from their perspective. Teaching practices related **Student Grouping** and **Social Interactions** were referenced by a handful of instructors to influence perceptions of Usefulness, particularly by providing an opportunity to work as part of a team where working as part of a team was a learning objective of the game, or where instructors expected their interactions with students during gameplay to prompt students to think more deeply about the experience and self-reflect on what was useful to them.

4.1.3. Instructors: Success (S)

Success was the most varied MUSIC component in terms of the categories of teaching practices that instructors expected to affect student perceptions of it. However, as in the case of usefulness, teaching practices related both kinds of **Task Structure** stood out across cases. Most other OPAL categories were also cited by instructors to a lesser extent. Particularly, some instructors expected that means of tracking progress (**Recognition and Feedback**), seeking help from their peers (**Help-Seeking Strategies and Responses**), relying on and knowing about their groupmates (**Student Grouping**), time constraints (**Use of Time**), and the ability to define their own markers of success (**Autonomy**) would affect student perceptions of Success.

Task Structure of the Game was cited by all instructors to affect student perceptions of success, most prominently their games' levels of difficulty. Some instructors asserted that their games being easy to play or win would bolster students' perceptions that they could be successful during play, and others conversely argued that their games being hard to win may hamper those perceptions. Victoria's chemical process optimization game offered an example of both situations, as she perceived it as being easy to avoid doing poorly (leading to higher perceptions of Success) but difficult to do very well (limiting the amount of Success most students will experience):

> *I think everyone should be well-placed to run things a few times and improve, so I think that success level should be nearly universal. I think actually being the one who finds a path to [optimally] making more product than anybody else...that is a fair challenge. That is a little bit difficult. So, doing okay should be, they should be well prepared for [that]. Doing very well is probably going to go to one of the Excel wizards who knows how to get the thing to run cases automatically.*

Additionally, some instructors included materials in their games intended to help students be more successful, including rules reference sheets, physical markers to track progress, and means to keep track of important parameters.

Six instructors also anticipated that their methods of briefing the game—as part of **Task Structure Before/After the Game**—would contribute to students' perceptions of their abilities to succeed by explaining the game's goals, rules, and constraints, either verbally or through written documentation. Andrew, for example, described how he expected the materials available to students to ensure that students knew what to expect during the game, improving student perceptions of Success by making it clear what they need to do in order to succeed:

> *[Students will] know what's expected of them in the game, because we printed out the rules. Everybody's going to have a copy of the rules. It tells them...specifically what to do in any scenario, so everybody has a role. You pull a bead out, look at the bead, what happens, and then they'll know. They have, also, a bunch of endgame scenarios on the back, so they know when the game is over.*

One instructor, Emily, even asked students to submit an initial plan for how they would play the game, and offered students feedback on their plans prior to play. She expected this feedback to improve student perceptions of Success.

A slight majority of instructors expected that **Recognition and Feedback** practices would increase students' perceptions of Success by giving students a means of tracking their progress. These teaching practices included maintenance of leaderboards, tracking of in-game scores, and incremental victory opportunities in games with multiple rounds. When describing his engineering ethics card game, for example, Andrew stated that he expected round-by-round victories to be the most significant markers of student Success by providing validation from their peers:

The win condition for Cards Against Humanity [the commercial game on which Andrew's game was based], and these card type games, is accumulation of points, and those points are represented by how many rounds you've won, or how many rounds you've been judged to have the winning combination. ... I play Cards Against Humanity where I never really care about the points, it's more about winning a particular round with a particularly funny or witty combination.

A small number of instructors also expressed that students could use **Help-Seeking Strategies** to leverage their peers to boost their chances of success, both in terms of sharing knowledge and helping one another learn the rules. Additionally, some instructors expressed that relying on others in constrained settings and having knowledge of groupmates—both related to **Student Grouping**—would affect student perceptions of Success. Two instructors conflicted in their expectations of how **Use of Time** would affect student perceptions of Success. One instructor believed that having time constraints might make students feel less capable of succeeding, while another believed that finishing a task "early" in a time-constrained setting would make students feel more successful. Finally, Emily believed that her students would define their own milestones for success, such as finishing a round early (**Autonomy**.)

4.1.4. Instructors: Interest (I)

Instructors expected that various aspects of the **Task Structure of the Game** would most influence student perceptions of Interest. Most instructors also expected that their games' competitive elements and prized (**Recognition and Feedback**) would impact student perceptions of Interest. Teaching practices in several other OPAL categories were infrequently cited as expected to influence student perceptions of Interest, including offering reflection questions prior to play (**Evaluation and Assessment**), getting to learn about multiple roles in a team working environment (**Student Grouping**), and interacting with friendly and supportive facilitators during gameplay (**Social Interactions**), and freedom to play the game how they liked (**Autonomy**).

All instructors agreed that the **Task Structure of the Game** would influence how interesting students found the game, via several factors involving fun, novelty, relatability, and real-world usefulness. Four instructors stated that they thought their games were fun to play, and one described his game as a "party game." Five instructors stated that their games would introduce some aspect of novelty into the classroom, such as a new setting, a new approach to teaching, or just giving students the chance to see a game used in an engineering classroom context. For example, Andrew expected that seeing a card game used to introduce engineering ethics would be perceived by students as a novel way of learning about engineering content:

> *I think they're all pretty familiar with Cards Against Humanity [the commercial game on which Barry's game was based], and so I think that seeing how that is contextualized for engineering material is going to be intriguing to them. So, I think that's what's really going to grab them about it.*

Two instructors believed that students would be able to relate to their games' topics and similarity to popular commercial games, and two others believed that their games' parallels to real-world engineering scenarios would capture student Interest.

Additionally, four instructors believed that having some **Recognition and Feedback** for game winners would increase interest in the game, and included this recognition in the form of competition for a material prize, extra credit, or bragging rights among classmates. For example, Emily described how team competition in her manufacturing simulation game helped keep students interested in the game by creating a sense of intrigue around strategic approaches to the game:

> *It seems like the little bit of competitiveness that's there, where if you have the highest profit, you get more points, seems to increase motivation, too. I'm not sure that I like that, but anyway, I think it does. ... They'll come up to me and say, "We're thinking about doing this," you know, like whispering. They don't want other people to know what their strategy is. So I think that they're interested in coming up with the best plan they can without giving away any secrets.*

A handful of other teaching practices in other OPAL categories were cited rarely by instructors to influence student interest. One instructor believed that offering reflection questions prior to the game would increase student Interest by prompting them to consider those questions during gameplay (**Task Structure before/after the Game**.) Another instructor felt working together in a role-based team would interest students both in learning about different roles, and in getting a chance to work in a team (**Student Grouping**.) The same instructor expressed that having friendly, supportive facilitators would help students find the game more enjoyable (**Social Interactions**.) Finally, Barry believed that students having the freedom to judge response cards as they saw fit (**Autonomy**) would bolster their perceptions of Interest.

4.1.5. Instructors: Caring (C)

There was little agreement amongst instructors about the teaching practices that would affect student perceptions that instructors cared about their experience, with the exception of **Social Interactions**. Most instructors believed that being friendly, encouraging, and attentive to students during the game would demonstrate Caring. When Andrew was asked how he felt his caring would manifest during the game, he responded:

> *I think that going around, asking them how they're doing, asking them what they thought was interesting that they've seen so far is also going to help manifest I care that [they] are actively engaging with this activity.*

Similarly, when asked the same question, Emily responded:

> *I asked some probing questions [during their preparation for the game], to encourage them to think through some of the decisions they had made. ... I think the whole atmosphere that night...demonstrates some caring, too. We'll be friendly with them, we want the GTAs to be friendly with them, and help them succeed.*

Miray also discussed that she expected her interactions with students outside of normal class time via regular one-on-one meetings to demonstrate caring.

Other teaching practices instructors expected to affect students' perceptions of Caring were divided among several OPAL categories. Two instructors believed that deciding to use a game at all demonstrated that they cared about students' learning experiences (**Task Structure of the Game**.) Two other instructors sought to provide extra help to students via extra office hours, probing questions to guide students, and help troubleshooting problems, which they believed would display that they cared about student success during the game (**Help-Seeking Strategies & Responses**.) In both his cases, Andrew believed that helping to connect the gameplay experience to student success, learning objectives, and/or future course content would demonstrate that he cared about student learning (**Task Structure before/after the Game**.) Finally, Victoria expected that maintenance of her game's leaderboard and the inclusion of a material prize would demonstrate that she cared about student experience (**Recognition and Feedback**.)

4.2. RQ2. Student perceptions of teaching practices and student motivation

As was the case with instructor expectations, students perceived that different categories of teaching practices affected their motivation differently, based on the MUSIC Model components about which they were asked. For example, students believed that instructors' briefing and debriefing processes (Task Structure before/after the Game) had a greater impact on their perceptions of Usefulness, while the way instructors designed their games (Task Structure of the Game) was more impactful for their perceptions of Success and Interest. Recall that students were not asked about OPAL categories directly, but the interview protocol was structured according to the MUSIC model. Table 13 exhibits the number of students citing teaching practices in each OPAL category as affecting each MUSIC component. As a reminder, these results combine students across cases for a cross-case analysis, and results from individual cases can be found in Appendix D. There were 22 students total. The remainder of this section will further dissect each OPAL category to qualitatively describe the nature of teaching practices cited to affect each MUSIC component, as well as highlight some salient institutional differences between student responses.

Table 13: Number of students citing teaching practices in a given OPAL category as affecting student motivation via a given MUSIC component (n = 22)

	MUSIC Component				
OPAL Category	**M**	**U**	**S**	**I**	**C**
Task Structure of the Game	15	12	18	21	1
Task Structure before/after the Game		20	7	9	13
Authority	2		3		
Autonomy	19	2		2	
Recognition and Feedback			8	14	
Student Grouping	14	4	7	12	
Evaluation and Assessment	4	5	8	2	8
Use of Time		2	8	6	1
Social Interactions		3	10	10	15
Help-Seeking Strategies and Responses			10	2	6

4.2.1. Students: Empowerment (M)

Similarly to instructors, students across all seven cases discussed the kinds of freedoms available to them throughout the game-based learning activities (**Autonomy**) as having the greatest effect on their perceptions of Empowerment. Students also placed a strong emphasis on how the design of the games sculpted and restricted their Empowerment (**Task Structure of the Game**) and on the kinds of input they had regarding with whom they worked and what roles they played within groups (**Student Grouping**). A few students also perceived that their Empowerment was affected by the fact that some games were not graded (**Evaluation and Assessment**) and the fact that one game's rules were unclear regarding how much adaptation was allowed in terms of deviating from one's role (**Authority**).

With respect to teaching practices under **Autonomy**, students placed a greater emphasis on the freedom they were able to exercise within the game's ruleset, without instructor encouragement. Sixteen students across all cases either stated that they were able to exercise meaningful choice within the game's rules, or offered specific choices they were able to make, such as how to interpret rules and takeaways, how to go about learning and seeking help, and strategic decisions. For example, one of Emily's students described that his instructor gave students the means to makes their own strategies and then set them loose, empowering them to strategize as they saw fit:

> *[Emily] gave you a big oversight forecast of how she thinks things are going to go [with the game's product demand], and then that was it. Everything else, from how you were going to break up the labor between each quarter, into each period, how many products you were going to make, how many supplies you were going to order...we had to decide what we were going to do.*

Several students also appreciated when instructors explicitly pointed out opportunities to take advantage of the autonomy that game activities offered. Four students across three cases felt their instructors gave them some control of the direction of the debrief discussion—and one from another case suggested the opposite, saying her instructor's discussion felt rather fixed, disempowering students from steering the conversation. Moreover, some students from two of the simulation game cases (those of Emily and Belinay) stated that their instructors provided specific information or tips meant to encourage or guide creative implementation, including recommendations of strategies, encouragement to adapt to new situations and data, and encouragement to apply course concepts. For instance, one of Belinay's students commented how her instructor encouraged students to apply supply chain management policies they learned in class during the game, but ultimately left decisions up to students:

> *Instead of telling us, "This is what you should do," ... she gave us some suggestions, like, "You can use these policies to come up with the best method." But she really gave us the freedom to decide on our own [what to implement] and see what would work and what wouldn't work.*

Like their instructors, 16 students across 6 cases cited the **Task Structure of the Game** as a restrictor of Empowerment. They noted that the rules of the game defined the scope of student empowerment in terms of the manipulable parameters and available actions, but otherwise restricted student empowerment by imposing rulesets, uncontrollable randomness, or restrictions upon student interactions. One of Miray's students illustrated one such restriction when discussing how her team's assigned cultural traditions both guided and limited the kinds of empowerment she had in interacting and trading with the other culture:

> *We were allowed to pick the leadership roles and who was going to be what [role] in the simulation. ... We had a lot of control over the conversations, but the rules kind of took some of that away from us. But it wasn't like [Miray] did; it was just the game.*

Fourteen students across six cases also discussed that instructors' policies on **Student Grouping** for the game activity affected perceptions of Empowerment. Students across four cases noted that having input into team composition strengthened their sense of Empowerment, while lack of input weakened it. One student noted that in cases where team composition is based on sitting proximity, effects on Empowerment can be mixed—she was unable to find a partner as everyone around her had already formed a group. Students across a different set of four cases also stated that selection of roles strengthened perceptions of Empowerment while randomization of roles weakened them. One of Emily's students also noted that the ability to only play one role was disempowering. As he put it:

> *[Roles] were chosen within the group, but then...you're stuck with it. So if you had two people that wanted to be president, or two people that wanted to be production supervisor, only one can. Maybe someone's unhappy with it.*

A handful of students across two cases also noted that because the game activity was not graded, they felt no pressure to come up with a "right answer" and could play as they liked, and/or recognized that participation was technically optional (**Evaluation and Assessment**.) Finally, in a rare occurrence of the **Authority** category, two students in Miray's case explained that rules were unclear regarding how much deviation one's role was allowed, which disempowered these students from adapting for fear from breaking the rules.

4.2.2. Students: Usefulness (U)

Like the instructors, almost every student across all cases believed that instructor debriefing (**Task Structure before/after the Game**) was critical to perceptions of usefulness. Several students also cited the design of the game itself (**Task Structure of the Game**) as affecting their perceptions of usefulness, but with less frequency than suggested by instructor expectations. Furthermore, when discussing each OPAL category, students in one case in particular (Emily's case) stood apart from other cases in terms of how teaching practices affected perceptions of Usefulness. Differences in Emily's case were particularly noted regarding the value of reflection activities and of the game activity being graded (**Evaluation and Assessment**), how involved instructors were in guiding students and prompting student reflection during gameplay (**Social Interactions**), a chance to work in a team with well-defined roles (**Student Grouping**), the experience of working under time pressure (**Use of Time**), and students having the freedom to figure out solutions to problems on their own (**Autonomy**).

In terms of the **Task Structure before/after the Game**, in addition to class discussions—which were the instructors' emphasis—students valued hearing the instructor's perspective on the game's usefulness, and appreciated when the instructor related the game back to course concepts and highlighted the differences and similarities between the game and real-world engineering. When asked what her instructor did to make the game feel useful to her, one of Miray's students stated that the debrief after the game helped tie the experience together and relate how the game might be applicable to professional life:

> *Definitely a little talk at the end about tying [the game] together...and also guiding us into how [the gameplay experience] could be useful down the line. She does that a lot...after class, she tries to do something like that...and it makes me feel like I didn't waste the last hour.*

Three students across two cases expressed a desire for a more in-depth debrief, particularly in regards to discussing solutions to real-world problems that were paralleled in gameplay.

Unlike the instructors, half the students (across six cases) cited the **Task Structure of the Game** as contributing to their perceptions of usefulness. Those who did overwhelmingly appreciated game elements that they perceived as "realistic," and some expressed mild disappointment in mechanics that they considered shallow or oversimplified representations of reality. For example, one of Emily's students expressed that he appreciated the game's attempt to expose him to a realistic manufacturing situation, but also that he felt the game's mechanics were an oversimplification of reality.

> *As far as like, usefulness in the actual working industry, it's too simplified to actually be useful, but it was good to get an idea of how it might be in industry. It was obviously a game played in five hours, so no matter how well you do it, it's still going to be simplified, but it did give a good example of how the randomness of things will affect how you have to operate as a manufacturing facility.*

At this point, I will note that Usefulness was one MUSIC component where students responses in one case—Emily's case—substantially deviated from student responses in other cases. Emily's case stood apart in many ways, and more details regarding her case can be found in Appendix D. Particularly, whereas other cases were one-off game activities for which students had little or no time to prepare, Emily's game was the capstone activity of her production planning course, about which students were aware for most of the semester, and for which students prepared for several weeks before the game started. Of the four simulation-type games I studied, hers was also the highest fidelity in terms of engineering tasks. It was also the only game I studied where students were graded on their planning and reflection work for the game. Perhaps for these reasons, students in Emily's case placed greater emphasis on the Task Structure of the Game rather than the debrief as influencing their perceptions of usefulness, contrary to other cases. Emily's students also offered unique perspectives on teaching strategies in other OPAL categories.

Evaluation and Assessment was one such category, where three students across two other cases provided mixed reception to structured reflection activities. Two students from Miray's case found the written and oral reflection activities useful, but one suggested that doing both written and oral felt a bit overbearing. One student from Barry's course stated that he found the reflection discussion too shallow to be useful. In Emily's case, two students discussed that the game activity being graded made it inherently useful to their academic success.

Social Interactions also played a moderate role in influencing Usefulness in some cases. In Barry's case, students appreciated when instructors helped connect card topics to the real world during the game. In Andrew's two cases, some students appreciated that the instructors were active in prompting students to think more deeply about the games during play, making the activities seem more useful. As one of Andrew's students put it:

> *[The instructors] asked pointed questions whenever they were walking around during class. These pointed questions made you think more about what they wanted you to think about, and it really just guided your thoughts to the end solution that they were wanting you to get to.*

Emily's students also offered unique perspectives in terms of **Student Grouping**, **Use of Time**, and **Autonomy**. Regarding **Student Grouping**, three of Emily's students stated that working in a large team was a useful experience—notably, this was also one of Emily's learning objectives for the game. Moreover, roles within each team influenced student perceptions of Usefulness during this game. While students appreciated the realistic nature of each role, some lamented that some roles were more interesting than others (both in terms of learning and gameplay), and that each student could only take one role. Regarding **Use of Time**, two of Emily's students found it useful to have experience working under time pressure, as they viewed such work as necessary in industry. Regarding **Autonomy**, two of Emily's students appreciated that the instructor limited her interactions with students and let students figure out solutions to situations on their own, making the activity more realistic.

4.2.3. Students: Success (S)

As for instructors, Success was the MUSIC component that features the widest variety of student responses in terms of the OPAL categories discussed. While at least one student touched upon each OPAL category except **Autonomy**, the most teaching practices related to the design of the games (**Task Structure of the Game**) by a wide margin. A wide variety of other teaching practices were also cited by students during interviews as affecting their perceptions of success, with only **Authority** lagging behind the other OPAL categories in terms of frequency.

Regarding **Task Structure of the Game**, Thirteen students across five cases noted factors in the design of games that improved their perceptions of Success. These included seeing plans or adaptations yield successful results, the game being simple/familiar to play or learn, inclusion of a practice round, and overcoming a challenging learning curve. For example, when asked what helped her believe she could be successful during the game, one of Barry's students commented on how the game's similarity to a popular commercial game and simple rules helped everyone learn to play quickly:

> *I think the fact that we all knew going into the game how to play the game was definitely helpful. ... It's not a particularly difficult game to understand how you play it. And so we all knew how to play the game [because of it's similarity to the commercial game] and then after that, it was just being able to pick cards that everyone else thinks they're funny or everyone else likes. ... One of the girls in our group had never played it before, but it took two seconds to explain and one round for her to see how it really works.*

Another 13 students across a different set of five cases also noted several elements of game design that were detrimental to their beliefs about success. These included obstacles and intended failures built into gameplay, low confidence in the efficacy of plans or preparation for the game, losing a competition, high difficulty to achieve a win, high learning curves, and uncontrollable randomness. As an example, one of Miray's students commented that near the beginning of the game, as students stuck to their roles' cultural traditions and tried to trade with others with conflicting cultural traditions, she felt frustrated and unable to be successful:

> *I was getting frustrated that I couldn't communicate with them and it didn't seem like anyone was having any more success. So I just wanted to get other people's thoughts on how we could best break into their ranks, I guess.*

Ten students across five cases commented on instructors' **Social Interactions** with them during the game sometimes bolstered their beliefs that they could be successful. These interactions were ones that manifested instructor approachability, encouragement and positive reinforcement, maintenance of a positive atmosphere, empathy, and a learning orientation—emphasizing takeaways rather than winning. When asked how his instructor supported his team's success during the game, one of Emily's students explained how Emily accommodated students who needed more time, and communicated a learning orientation:

> *I think being understanding throughout the situation. Sometimes our material for the products wouldn't come on time, so she was like, "Don't worry, I'll give you guys an extra few minutes to get it, because it's not your fault." I think also that she understood that it was a learning experiencing, even though it was competitive. She did the game because it helped us learn the concepts in class. I thought that was very helpful.*

Similarly, ten students across four cases noted that instructor help during or before the game—answering questions, troubleshooting “stuckness”, and giving accommodations, guidance, or hints/tips where appropriate—helped them be successful (**Help-Seeking Strategies and Responses**.)

Eight students across five cases also noted a handful of situations in which the game briefing process (**Task Structure before/after the Game**) affected their perceptions of Success. Most students stated that instructors’ communication, justification, and demonstration of rules prior to play contributed to their beliefs that they could be successful during the game. One of Emily’s students noted that having information about distributions of randomness in the game contributed to his success. Finally, a handful of students across two cases stated that perceptions of success were hindered when some rules of the game were ambiguous, or when prep work prior to the game was not reviewed or verified by the instructor. For example, after commenting that she thought her instructor explained the game well, one of Victoria’s students stated that she would have liked more preparation time to ensure her spreadsheet simulation was working prior to the game’s start, and therefore she would know that she had successfully prepared for the activity:

> *I think we didn't go over it completely enough in previous classes to make sure that everyone had a working spreadsheet. That confusion, not being able to confirm if you're doing it exactly correctly the day of, wasn't the most motivating.*

Eight students across six cases also discussed both formative and summative **Evaluation and Assessment** as affecting their perceptions of success. Formatively, six students appreciated when instructors checked up on students/groups throughout the game, including asking about student decisions. Summatively, two students stated that the fact that their game activities were not graded helped reduce their sense of pressure that they needed to be successful. To illustrate the latter, when asked what helped her believe that she could be successful during the game, one of Barry’s students responded:

> *Maybe the fact that there wasn't any pressure to do well during the game. Made me feel like it was okay, and that I could do well in the game, because we weren't graded on the number of yellow cards [successful round wins] we got or anything like that. None of our answers were recorded. There wasn't any pressure on us doing well, which helped me feel safer in a sense.*

In three cases with simulation games that had restrictive time constraints, eight students had mixed responses regarding how **Use of Time** affected their perceptions of Success. Some students appreciated a fast sense of pacing, and some felt successful when they managed to finish a round early. One of Emily's students described that finishing a round earlier than the enforced time limit make him feel successful:

> *We felt successful because we were able to like all get our tasks done in a very short amount of time. So we had like enough time to break after [each round], so we really felt like we made progress there.*

Contrarily, students in Victoria's case believed that they needed more time for individual help during the game, and/or that the game's time limits adversely affected a sense of success. One student in Emily's case wished he had more prep time prior to the game.

Recognition and feedback for winners was also a category with mixed interpretation regarding student perceptions of Success. Six students across three cases noted that instructor maintenance of a leaderboard helped them keep track of their progress, and/or that doing well (or at least not poorly) compared to their peers helped them feel successful. Conversely, four students across two of those same cases stated that doing poorly compared to their peers was a detriment to their sense of Success, and one student in Victoria's case commented that having individual competition between students was detrimental to success by dissuading peer help-seeking.

Seven students across six cases also discussed **Student Grouping** as affecting their perceptions of success. Several students noted that working in a group boosted morale and sense of success. However, one student in Victoria's observed that when groups were self-selected, the expected front-runners of her class all clustered together, which was a detriment to the success of others in a competitive setting:

> *Everyone sits near their friends, and there are definitely different groups that you know will get to certain decisions before others. And so, when the activity started, I'm pretty sure everyone in the class knew exactly who was going to get the highest number. ... Trying to get there before them is kind of useless.*

Success was also another rare example of teaching practices related to **Authority** being cited as affected student motivation, this time in three different cases. Two students discussed taking actions that were not specifically allowed in the rules to boost their chances of success, and expressed uncertainty if they had cheated or not. One student in Andrew's random draw game case described that her team made a deal with another team after losing due to bad luck; they "bought" data about the contents of the other team's bag and used that data and bag to make more informed decisions when they played again:

> *The second bag that we chose, there was a group beside us that had that bag, and so they sold their data to us for a certain amount of [in-game] money, so that we could pick what colors we wanted based on their data. ... Knowing that the other group had only purchased [insurance for yellow draws], we purchased two [insurances for yellow draws] right off the bat and that was it. So we were already kind of in the plus side [in terms of] money. So yeah, it definitely made me feel more successful.*

Conversely, one student in Miray's case noted seeing a student deviate from a strict interpretation of the rules, and this made her actions as a rules-follower feel disrespected, damaging her sense of success.

4.2.4. Students: Interest (I)

Interest was another MUSIC component that spanned many OPAL categories, but where various practices relating to the design of the game (**Task Structure of the Game**) was the most discussed by a large margin. Many students also referenced an assortment of other teaching practices as affecting their perceptions of Interest, including briefing and debriefing processes (**Task Structure before/after the Game**), inclusion of competition (**Recognition and Feedback**), working with other people and roleplaying (**Student Grouping**), and humorous interactions with instructors and classmates (**Social Interactions**). Less commonly cited teaching practices for Interest included game pacing and duration (**Use of Time**), and whether or not a game was graded (**Evaluation and Assessment**), instructors' efforts to help students that were stuck (**Help-Seeking Strategies and Responses**), and having the freedom to play how they wanted (**Autonomy**).

Regarding **Task Structure of the Game**, nearly every student across all cases asserted how the game's design affected their Interest. Student responses tended to fall into one of six themes: (1) Statements that they found the game fun or funny; (2) beliefs that the game introduced novelty in terms of new teaching methods, classroom settings, class activities, or anticipation of results; (3) assertions that the game's level of challenge kept them interested, or that they lost interest in a game with too high a learning curve; (4) assertions that the game was intellectually engaging; (5) statements that the nature of interactivity within the game bolstered Interest; and (6) beliefs that the games or the games' content were relatable. To illustrate some of these themes, when one of Belinay's students was asked about her motivation during the game, she responded that she found the game to be fun, interactive, and a novel way of learning for the course:

I was really motivated. I think it was a lot of fun; it was a good, different way to start to learn about [supply chains] as opposed to what we typically do is a bunch of math on the board. But it was a good way to see that in action and have it be an interactive activity.

In addition, 9 students across all cases believed that the framing of the game in the **Task Structure before/after the Game** affected interest. Teaching practices students cited included explaining the game's usefulness in the brief or debrief, hearing other students' approaches to play in the debrief, and setting milestones for students to reach during the brief. As an example, the same student from Belinay's case summarized how she felt her instructor's framing of the game helped foster student Interest beyond just the novelty of using a game:

[Belinay] told us a week before class we were going to be playing a game next week, so obviously that kind of, "Ooh, we're playing a game instead of doing more derivatives" [was present]. But I think explaining it at the beginning and making sure we understood why we were doing it was important as well. I think that was definitely very beneficial and kept people interested for more than just the fact that it was a game.

Teaching practices related to **Recognition and Feedback** were cited by 14 students across six cases as a major influencer of Interest perceptions, as competition was a major Interest motivator in all cases where competitive elements were introduced—which excluded only Andrew's random draw game. Unlike for success, where competition was a positive influence for winners and a negative influence for losers, competition was unanimously accepted by students as a positive factor for Interest across cases. One of Victoria's students explained why competition was a key intrinsic motivator for her:

There was chocolate in a cup at the end, which would have been kind of fun to get. But I think definitely for me, the bigger driving factor [for motivation] was wanting to be competitive against my classmates. I think that this major [chemical engineering] is very competitive to begin with, so it was almost like proving yourself that you were able to make a profit [in the game].

Twelve students across four cases asserted that **Student Grouping** was also influential for Interest. In most cases involving teams, students enjoyed working with others, and expressed that their teammates helped them maintain high morale and situational interest. Role-playing was less commonly cited in relation to Interest, but two students in Miray's case expressed finding the rules of their roles interesting. Like interacting with other students in teams, ten students across six cases cited instructor-student and other student-student **Social Interactions** as affecting perceptions of Interest, particularly when these interactions were funny or included jokes.

Use of Time also influenced student perceptions of interest, with four students across three cases saying that games were well-paced to maintain interest and engagement, and two students in two other cases expressing that they felt gameplay went on for too long, causing interest to wane. Also, One student from Miray's case stated that the low-stakes, ungraded nature of the game contributed to her perceptions of Interest, while another student in the same case felt that asking for both written and oral reflection was a bit much (**Evaluation and Assessment**.) Two students from Victoria's case appreciated that their instructor took time to help students who were stuck so they could get back into the game (**Help-Seeking Strategies and Responses**.) Finally, two students across two cases appreciated that they had the freedom to play the game and experiment as they wished (**Autonomy**).

Many students also stated that they felt the game was related to their personal and professional interests, which related closely to the Individual Interest portion of the MUSIC Model's Interest component. However, because these statements were not able to be categorized under OPAL, and because the instructors did not talk about if or how they tailored their games to individual students' interests, I omit describing these statements.

4.2.5. Students: Caring (C)

Students cited a wider range of teaching practices as affecting Caring than their instructor counterparts. Various kinds of **Social Interactions** and debriefing practices (**Task Structure before/after the Game**) were cited most frequently as increasing student perceptions that their instructors cared. Some students also discussed their instructors' **Evaluation and Assessment** activities and availability for **Help-Seeking Strategies and Responses** as affecting perceptions of Caring. Finally, **Task Structure of the Game**, and **Use of Time** were all infrequently cited by students as affecting perceptions of Caring.

Many of the same kinds of instructor-student **Social Interactions** students cited to bolster Success were also cited by 15 students across all cases to affect their perceptions of instructor Caring. These interactions were ones that demonstrated instructor attention, encouragement, maintenance of a positive atmosphere, empathy, and a learning orientation. Moreover, student responses reinforced that instructors build a sense of caring over time, rather than just as the result of one-off actions during game activities. Some students cited instructors as demonstrating caring through means such as learning student names, checking in on student lives, and generally trying to make class fun, engaging, and worthwhile for students. For example, the student interviewee from Andrew's engineering ethics card game case expressed that the instructors did their best to make the class fun and useful for students:

> *[The instructors] definitely want to try to make that class pretty fun...they've tried to work with students a lot to make sure that it's not just something [students] have to do, it's actually beneficial. So I feel like they make sure we get a lot out of it.*

Thirteen students across all cases also emphasized the **Task Structure before/after the Game** as an opportunity to demonstrate Caring. Particularly, students cited many of the same debrief practices that bolstered Usefulness—including involving students in discussion, explaining the game's relevance, and connecting the gameplay experience to learning objectives or real-world engineering tasks—as evidence that their instructors cared that they learned from the game activity. Moreover, students stated that instructors demonstrated caring about students as individuals by soliciting student input during discussions and using the game to teach things that are relevant to life beyond university. For instance, one of Miray's students discussed how her instructor's methods of soliciting student input during the debrief helped demonstrate caring:

> *The question sheet that she gave us [after the game] helped collect our thoughts before we talked as a group, which I found helpful because sometimes just trying to come up with my ideas on the fly doesn't go so well. Being able to think about it and then talk about it, it made me feel like she cared actually what we were saying.*

One OPAL category that surprised me as a contributor to Caring was **Evaluation and Assessment**, but eight students across five cases described their instructors' assessment practices as demonstrating that they cared about student learning and experience. Particularly, they stated that asking for feedback on the activity demonstrated that instructors cared about student perspectives and experience, and using structured reflections demonstrated caring about student learning. One of Emily's students summarized student sentiment well when asked how Emily demonstrated that she cared:

> *The self-reflection afterwards. She really wanted to make sure we had some key takeaways from [the game]. Mostly, writing the final report up, and getting the surveys back from it. I think her trying to get the feedback on the game, and just getting feedback in general, showed that she actually cared.*

Help-Seeking Strategies and Responses were influential signs of caring in two notable cases where students needed a higher degree of instructor support (Emily's case and Victoria's case.) Students in these cases appreciated instructors going above-and-beyond to help them prepare for the game or resolve issues. A handful of other OPAL categories were touched upon by one student each to influence student perceptions of caring, particularly **Task Structure of the Game** and **Use of Time**.

4.2.6. Students: Institutional differences

As part of my analysis, I made a comparison by institution type—research and teaching universities—as one might pragmatically expect differences. Most of the differences likely derived from individual differences between the kinds of games used between the two types of institutions, which were likely due to chance rather than any fundamental differences between institution types rather than school type. For example, the games used at research universities relied more heavily on teamwork and roles, and therefore Student Grouping was cited more frequently by students at research universities. Nonetheless, readers interested in a full presentation of differences can find a relevant table in Appendix E.

One difference that was easily explained by fundamental differences between institution types was that students at teaching universities tended to emphasize social interactions more often as affecting perceptions of Caring. This difference was likely due to the differences in class sizes between the teaching and research universities I studied, where students in most cases with high instructor/TA-to-student ratios (Andrew, Miray, Victoria, Emily) tended to emphasize individual interactions with instructors, while students in other cases did not.

An unanticipated difference noted between research and teaching universities was that that students at teaching universities much more often referenced instructor briefing and debriefing practices as affecting their perceptions of success. With the exception of Emily's long briefing process involving preparatory student work, instructors across all cases followed a similar structure in terms of how they briefed and debriefed their games. It seemed that students at teaching universities simply paid more attention to teachers' briefing and debriefing practices with respect to their perceptions of success, and this difference may be worth further exploration in future studies.

4.3. RQ3. Comparing instructor expectations to student perceptions

Instructors and students agreed that several key categories of teaching practices affected student motivation through each MUSIC component, but their responses also differed in a number of important ways. In this section, I compare and contrast instructors and students responses in terms of the OPAL categories each group emphasized as affecting each MUSIC component, as well as the relative emphasis each group placed on each MUSIC component when discussing student motivation. Of particular interest, students discussed **Usefulness** and **Interest** most prevalently when discussing what affected their motivation, and several differences between instructor expectations and student perceptions of what affected these MUSIC components—as well as **Success**—imply where recommendations for game-based teaching practice might have the greatest impact for student motivation. These comparisons yielded insights that are the focus of much of my discussion chapter.

4.3.1. Comparison: OPAL Category Emphasis

While instructors and students generally agreed on at least one OPAL category to be the main influence on student perceptions related to each MUSIC component, instructors tended to overemphasize the importance of one or two OPAL categories compared to students, while underestimating the range of teaching practices that students discussed as affecting each MUSIC component. Table 14 exhibits the differences in emphasis for each OPAL-MUSIC pairing between instructors and students. The difference in emphasis is normalized, and is calculated by subtracting the percentage of students that discussed a given pairing from the percentage of instructors that discussed that paring. For example, 6 of 7 instructors (86% or 0.86) cited Task Structure of the Game as affecting Empowerment, while 15 out of 22 students (68% or 0.68) did the same. Therefore, the difference in emphasis of Task Structure of the Game as affecting Empowerment is 0.86 – 0.68 = +0.18, indicating that instructors emphasized that OPAL-MUSIC pairing 18% more often than students did. If the number were negative, it would indicate that students emphasized the pairing more often than instructors. This table is not meant as a means of presenting a formal analysis of differences between the two groups, and readers should note that small differences between groups (at least those less than 0.15) are likely due to the small sample size of the instructor participants. Rather, this table is meant to serve as a visual aid to help readers quickly discern where and how prominently students and instructors differed in their responses. The remainder of this section will further describe these differences, focusing on pairings where the differences in emphasis were large.

Table 14: Instructor-Student difference in emphasis of teaching practices in a given OPAL category as influencing a given MUSIC component. Only differences with magnitudes greater than 0.15 are highlighted.

–  +

Students emphasized more | Equal Emphasis | Instructors emphasized more

	MUSIC Component				
OPAL Category	**M**	**U**	**S**	**I**	**C**
Task Structure of the Game	+0.18	+0.31	+0.18	+0.05	+0.24
Task Structure before/after the Game		-0.05	+0.54	-0.27	-0.31
Authority	-0.09		-0.14		
Autonomy	-0.01	-0.09	+0.14	+0.05	
Recognition and Feedback			+0.21	-0.06	+0.14
Student Grouping	-0.21	+0.10	+0.11	-0.40	
Evaluation and Assessment	+0.10	+0.20	-0.36	-0.09	-0.36
Use of Time		-0.09	-0.08	-0.27	-0.05
Social Interactions		+0.15	-0.45	-0.31	+0.03
Help-Seeking Strategies and Responses			-0.17	-0.09	+0.01

4.3.1.1. Comparison: Empowerment (M)

With regard to Empowerment, few differences emerged between students and instructors. Students and instructors were largely on the same page regarding sources of empowerment and disempowerment. Qualitatively, differences between the kinds of teaching practices they pointed out were negligible. Quantitatively, instructors moderately overemphasized the **Task Structure of the Game** and underemphasized **Student Grouping** compared to student responses, but these differences were not prominent enough to warrant further discussion.

4.3.1.2. Comparison: Usefulness (U)

Both instructor and students were on the same page that the **Task Structure before/after the Game**, particularly the debrief, was the most impactful OPAL category for Usefulness. However, while instructors considered **Task Structure of the Game** as influential as the debrief, students placed a much heavier emphasis on the debrief, suggesting that instructors may overestimate how self-evident their game's usefulness is to students. Qualitatively, regarding the debrief, students commented both that it was helpful to both have a discussion and hear the instructor's perspective on why the game is useful and relevant, while instructors placed a heavier emphasis on discussion. Regarding the structure of the game itself, instructors placed emphasis on a wider variety of factors that made the game useful. Students focused almost exclusively on the game's level of realism.

Additionally, instructors mildly overemphasized the role of **Evaluation and Assessment**, and tended to portray reflection activities in a positive light. When students commented on the impact of reflection activities, reception was mixed, with some student saying there was too much or too shallow reflection. This comparison suggests that instructors may need to more carefully hone their reflection activities to ensure high depth for a small number of takeaways.

4.3.1.3. Comparison: Success (S)

Instructors and students agreed that the **Task Structure of the Game** was the most impactful OPAL category for success, and generally agreed that simple and easy-to-learn mechanics contributed to success. However, instructors covered a narrower range of teaching practices than students, focusing primarily on the two forms of **Task Structure**. Conversely, while **Task Structure** encompassed the plurality of student responses related to success, students also emphasized **Help-Seeking Strategies and Responses**, **Social Interactions**, and **Evaluation and Assessment**. **Social interactions** represented the greatest discrepancy, suggesting that instructors may underestimate the impact of their interactions with students during gameplay on student perceptions of Success. These differences may be partially attributed to differences in instrumentation, as the instructor interview protocol was phrased more narrowly than the student interview protocol to focus on "aspects of the activity," but are significant enough to warrant discussion nonetheless.

Qualitatively, instructors vastly overemphasized the extent to which their briefing processes would affect student sense of success. While some students did appreciate clear communication of a game's rules, students as a whole emphasized other teaching practices more heavily. Also, instructors tended to focus on positive influences on Success, while students talked fairly evenly about both positive and negative influences. This difference suggests that instructors could more carefully consider not only how they can bolster student success, but also prevent factors that may detract from it, particularly in terms of **Task Structure**, **Recognition and Feedback**, **Student Grouping**, and **Use of Time**.

4.3.1.4. Comparison: Interest (I)

Similarly to Success, students and instructors agreed that **Task Structure of the Game** was the most prevalent OPAL category, but students covered a much broader range of teaching practices than instructors. In this case, instructors underemphasized *every* OPAL category except the Task Structure of the Game, some to a greater extent than others. This under-emphasis suggests that instructors may substantially underestimate the means by which they can impact student interest.

Within the **Task Structure of the Game**, students also covered a wider range of factors than instructors. Particularly, difficulty and intellectual content of the game were each mentioned by six or seven students as contributing to interest, while no instructors referenced them. Although less impactful than the Task Structure of the Game, several students noted that instructor interactions—both as **Social Interactions** during the game and in the framing of the game as part of the **Task Structure before/after the Game**—affected student interest. These interactions were rarely cited by instructors in relation to Interest. Finally, **Student Grouping** and **Use of Time** were two other areas that affected student interest that were substantially underemphasized by instructors. The establishment of compatible teams and an engaging pacing and duration for games

may be two areas where more attention is needed from instructors.

4.3.1.5. Comparison: Caring (C)

I must preface this section on Caring by acknowledging that there was a substantial difference in instrumentation between students and instructors in relation to this MUSIC component. Instructors were asked how their actions affected student experience during the game, while students were asked more specific questions about how instructors demonstrated that they cared whether or not students learned from the game and succeeded during the game.

This difference in instrumentation makes comparing across the two groups difficult. Nonetheless, I will describe the few differences that stood out.

Qualitatively, differences between student and instructor responses for caring were negligible, except for cases where instrumentation differences were the clear culprit. Students and instructors were on the same page about how their teacher-student **Social Interactions** during the game impacted student perceptions of Caring, with both considering it the most impactful OPAL category. Only one instructor (Miray) noted the impact out-of-activity, long-term interactions like several students did, but this difference was likely due to instrumentation differences.

One place where instructors and students disagreed was regarding **Evaluation and Assessment**—a significant number of students commented that instructors asking for feedback on the activity and preparing structured reflection activities demonstrated that they cared about student learning, but no instructor commented on their evaluation & assessment practices in relation to caring. This is also likely a result of instrumentation bias, as instructors were asked about caring in relation to student experience, not student learning.

4.3.2. Comparison: MUSIC Component Emphasis

Students and instructors displayed differences not only in the OPAL categories of teaching practices they emphasized as affecting each MUSIC component, but also in the emphasis they placed on each MUSIC component. Figure 4 displays the relative prevalence of each MUSIC component across interviews with both students and instructors. In this case, "prevalence" is a variable calculated by multiplying the number of teaching practices cited to affect each MUSIC component by the number of interviewees citing that teaching practice. Readers can interpret "relative prevalence" of a MUSIC component as an estimate of the average percentage of an interview spent discussing teaching practices affecting that MUSIC component, as opposed to teaching practices affecting other MUSIC components.

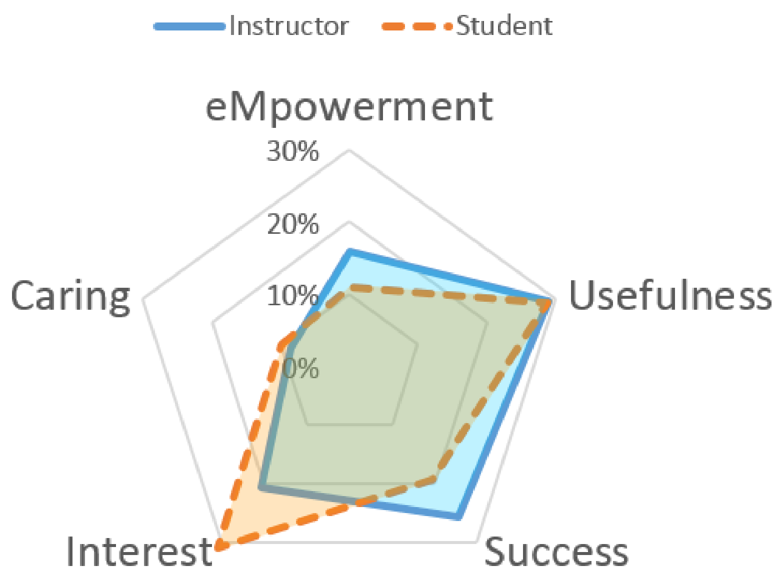

Figure 4: Relative prevalence of each MUSIC component across student and instructor interviews. Proximity of axes does not imply any relationships between MUSIC components.

As Figure 4 exhibits, instructors spent most of their interviews discussing teaching practices that they expected to affect student perceptions of **Usefulness** and **Success**, followed by **Interest** and **Empowerment**. Students spent a proportionate portion of their interviews discussing teaching practices that affected their perceptions of Usefulness, but placed a higher emphasis on Interest and a lower emphasis on Success and Empowerment, compared to instructors. This assertion was supported qualitatively in the data, most notably in the case of Victoria, where students had relatively low perceptions of Success, but were still motivated to engage with activity because they believed it was useful and the competitive elements kept them interested (see Appendix D for more details about her case and other cases.) The finding that Usefulness and Interest were the most prevalent MUSIC components across student interviews is important, as it contradicts most established literature on what motivates people to play games.

I will note that the differences in the prevalence of Success apparent in Figure 4 may be partially explained by differences in instrumentation between the two groups. Instructors were asked several specific questions about how they expected the game activity would affect student perceptions of success, including level of challenge, expectations, and progress tracking. Students, on the other hand, were asked more open-ended questions about how they perceived the game activity would affect their sense of Success. The more detailed line of questioning may have led instructors to talk more about success than students did. I do not suspect that differences in the prevalence of Empowerment or Interest were attributable to differences in instrumentation.

4.4. Addendum: Instructor experience and the importance of iteration

Before concluding my presentation of results, I wish to discuss an important characteristic of my cases that affected instructors' expectations for student motivation and consequentially their teaching practices. Namely, all the instructors I studied had prior experience implementing their games. Accordingly, each game activity I studied was the product of multiple rounds of iteration. Through these iterations, and through the process of getting feedback from their students in each iteration, each instructor was able to predict at least some of the most important teaching practices in terms of motivating their students. Moreover, each instructor described knowing to which behaviors they needed to pay attention or what kinds of data they needed to collect in order to assess student motivation in their classrooms. Instructors built this knowledge over time through iteration, signaling the importance of assessment, reflection, and iteration in designing and refining game-based learning activities.

While instructors in most of my cases were on their second or third game iteration, two instructors stood out from the rest as having much more experience with their games: Emily, who was on her 13th iteration, and Victoria, who was on her 7th iteration. Emily had refined her game over a dozen times based on formal feedback offered by students in the form of a final report each iteration, and thus her game activity was highly refined. She was able to smoothly manage what was easily the most complex game in my study, and her expectations of what would affect student motivation were closely aligned with student perceptions. Overall, Emily's case was a testament how streamlined and effective a game-based learning experience can become for a given classroom context, given an instructor's long-term commitment to its continual improvement.

Victoria's case, on the other hand, showed the importance of context in the game refinement process. Like Emily, Victoria had several years of experience iterating and refining her game-based learning activity to fit her classroom context. However, Victoria faced an unexpected barrier in that her department's curriculum had changed to the extent that students no longer arrived in her course with the prerequisite knowledge to play her game without a greater degree of preparation. Accordingly, her years of iteration in a particular curricular context were suddenly insufficient to predict how her new students would perceive her game activity in terms of student motivation. However, it should also be noted that Victoria's post-interview and member check revealed that her experience in iterating her game activity gave her the tools she needed to assess what did not go well, and to iterate her game appropriately given the change in curricular context. Overall, Victoria's case exemplifies the importance of context in the design of a game activity, and the necessity of assessment and iteration to appropriately adapt a game activity to a given classroom.

4.5. Summary

In this chapter, I presented the results of my dissertation study toward the goal of answering my overarching research question: **What is the role of student motivation in (1) instructor beliefs that influence their use of non-digital game-based teaching practices, and (2) student perceptions of these teaching practices?** In doing so, I have established four significant findings.

First, I found that instructors expect distinct categories of non-digital game-based teaching practices to affect different components of student motivation (as defined by the MUSIC Model of Motivation) differently. To instructors, the design of the game itself was emphasized to affect all MUSIC components except Caring. Different kinds of teaching practices were expected to supplement the game's design for different MUSIC components. For Empowerment, instructors emphasized the importance of giving students different kinds of meaningful choice, both during the games and in the games' debrief phases. With respect to Usefulness and Success, teaching practices embedded within games' brief, debrief, and preparation phases were considered important for student motivation. For Success and Interest, instructors emphasized means of recognizing winners and providing feedback on student progress within the game. Finally, instructors believed that instructor-student interactions during the game were most responsible for affecting student perceptions of caring.

Second, I found that students also perceived distinct categories of non-digital game-based teaching practices to affect their motivation differently. Students described a wide range of teaching practices as affecting their motivation, with one or two categories of teaching practices being the most prominent for a given MUSIC component. Regarding Empowerment, students emphasized the importance of having meaningful choice throughout game activities, as well as the impact of the game's design and student grouping policies in defining and restricting empowerment. When discussing teaching practices that affected Usefulness, students described the design of the game's debrief as being the most impactful by a wide margin. In terms of Success and Interest, students talked primarily about the impact of the game's design, but also discussed almost every aspect of teaching as affecting their perceptions of Success in some way, and a slightly narrower range of teaching practices as affecting Interest. For Caring, students emphasized the design of the game's brief and debrief, as well as teaching-student social interactions during the game as demonstrating that the instructor cared about their learning and experience.

Finally, I found that key differences existed between instructor expectations and student perceptions of how teaching practices affected student motivation, and in the degree of emphasis placed on each MUSIC component. With respect to MUSIC components, when talking about teaching practices affecting student motivation, Usefulness and Interest were discussed more often than other MUSIC components by students, while instructors focused more on Usefulness and Success. With respect to teaching practices, students discussed a much wider variety of practices as affecting their motivation than instructors. This difference was especially pronounced when discussing Success and Interest, where instructors generally underestimated the extent to which their actions throughout the game and surrounding activities would impact student motivation. Given the prevalence of Usefulness in discussions of student motivation in both groups, I will also note that instructors tended to overestimate the intended impact of their games' design in affecting student perceptions of Usefulness.

Chapter 5. Discussion and Conclusions

The purpose of my study was to answer the overarching research question: **What is the role of student motivation in (1) instructor beliefs that influence their use of non-digital game-based teaching practices, and (2) student perceptions of these teaching practices?** I answered this research question via a multiple case study of seven non-digital game-based learning activities from the perspectives of both instructors and students. In doing so, I have contributed to the knowledge base of game-based teaching practices by understanding how teaching practices were perceived to affect student motivation differently from both instructor and student viewpoints, and how these perceptions differed between the two groups. In this chapter, I interpret and discuss my results in relation to the extant literature on student motivation and game-based learning, offer concrete recommendations for engineering instructors using games in their classrooms and for game-based learning researchers, and present my conclusions concerning game-based learning implementation in engineering classrooms.

While much of the discussion in this chapter is teacher-centered, my ultimate goal is to advance game-based learning as a learner-centered pedagogy. Research on inductive teaching methods has revealed that—despite its moniker—learner-centered pedagogy functions most effectively when coupled with effective teaching and guiding practices from instructors (Prince & Felder, 2006). This conclusion has been echoed in game-based learning literature as well, where instructor facilitation and scaffolding have long been asserted as necessary components of effective game-based learning activities (e.g., Hays, 2005; Kangas et al., 2016). Accordingly, a teacher-centric discussion is a productive means of enhancing game-based learning as a learner-centered pedagogy, especially considering that my recommendations for instructors are derived from a combination of student and instructor data.

5.1. Transferability of results to digital game-based learning settings

As I discussed in my literature review, the vast majority of contemporary knowledge on game-based learning exists within the digital game-based learning space. Therefore, in order to compare my results to that contemporary knowledge, I will first establish the extent to which my results are transferable to digital game-based learning settings. To do so, I will compare the kinds of game-based teaching practices observed in my research to those captured in existing models of game-based teaching and teacher roles. At both a high level and a more granular level, the non-digital game-based teaching practices in my study closely resemble those of models proposed for digital game-based teaching practices.

Although work on game-based teaching to date is limited, a handful of high-level models exist that can act as useful points of comparison for my work. One of these models comes from a qualitative review of literature by Kangas et al. (2016), who present game-based teaching as an iterative cycle consisting of (1) planning a game appropriate for learning objectives; (2) orienting students to the educational topics, gameplay, and/or purpose of the game; (3) facilitating the game by helping students connect their in-game activities to learning objectives or real-world issues; and (4) leading a discussion of game content following play. This model of game-based teaching as a high-level, cyclical process is echoed by other models of game-based teaching and game-based learning. One such model of game-based teaching was proposed by Alklind Taylor (2014) based on a multiple case study of military and medical game-based training programs. She proposed that game-based teaching was an iterative, cyclical process involving (1) scenario authoring (designing or selecting games that integrate with learning objectives and prior student knowledge); (2) briefing to introduce learners to the idea of GBL and the game being played; (3) gameplay, in which players make decisions based on feedback from both the game and the instructor; and (4) debriefing as a means to help learners remove themselves from the game and reflect on their actions. Both models are shown in Figure 5. Kangas et al. (2016) and Alklind Taylor (2014) developed their models independently through research in different digital game-based learning contexts, and while each proposes different instructor objectives and roles for each of their four phases, their resounding similarities suggest that digital game-based teaching follows a fairly consistent cycle involving game selection and design, briefing, facilitation, and debriefing.

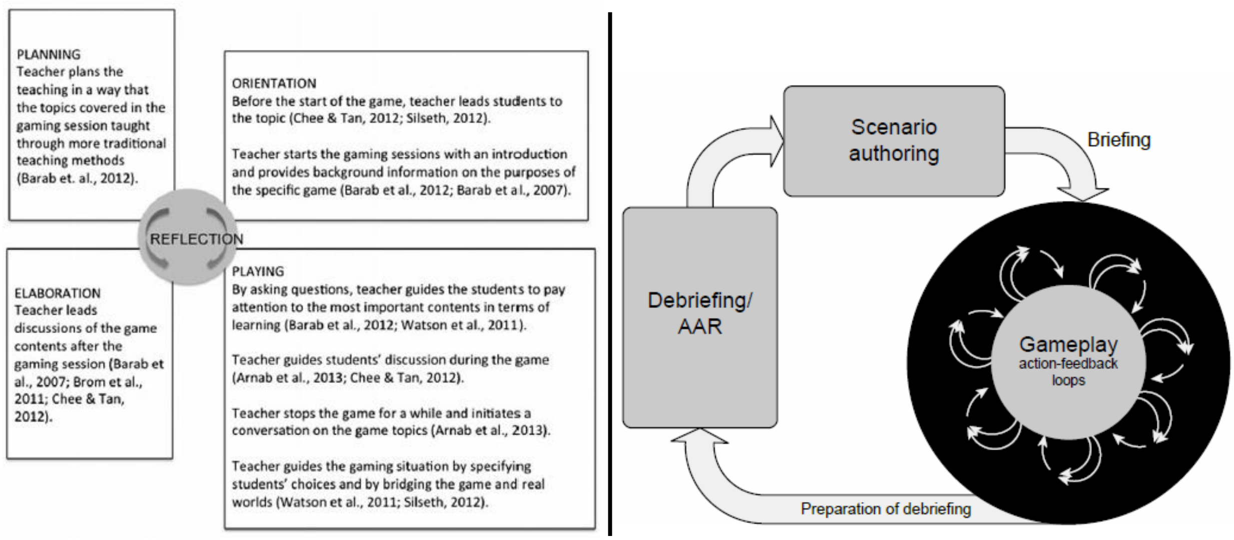

Figure 5: Model of game-based pedagogical activities from Kangas et al. (2016) (left) and game-based training Coaching Cycle from Alklind Taylor (2014) (right)

Every case in my study on non-digital game-based teaching followed the same high-level cycle. Every instructor I studied (1) had a story about how they designed or came across their game and how they adapted it to fit their classroom objectives and context; (2) began by briefing the game, its rules, and sometimes its objectives to students; (3) facilitated student gameplay; and (4) ended with an oral debrief and sometimes a written reflection to help students process their gameplay experiences. There were, of course, individual differences in the details of these phases—for example, Emily's brief lasted several weeks and involved students preparing strategic plans for gameplay, while all other cases conducted their briefing processes immediately prior to play (see Appendix D for more detail.) However, my cases suggest, at a high level, that the game-based teaching practices I studied are highly transferable to digital game-based learning settings.

Others have attempted to examine game-based teaching models at a more granular level by developing categories of teacher roles in game-based learning settings. For example, Hanghøj (2013), through several case studies, defined four roles he observed teachers adopt when using games: (1) an **instructor** who plans, communicates, and connects to the learning objectives of the game; (2) a **playmaker** who defines, communicates, and coordinates gameplay tasks, rules, and dynamics; (3) a **guide** who prompts students to reflect on their experiences and helps students who are stuck; and (4) an **evaluator** who assesses student outcomes both summatively and formatively. Alklind Taylor (2014) proposed a broader list of possible instructor roles, covering the range activities embedded in Hanghøj's roles while adding that instructors can also be **off-game facilitators** who take a passive, fly-on-the-wall approach during gameplay; or they can be active **players** along with students during play, though this role is reportedly uncommon. Both authors note that instructor roles are fluid during game-based teaching, and any given instructor would be expected to shift between roles throughout a game-based learning activity.

Although my cases had no purely off-game facilitators or instructor players, each of Hanghøj's roles was represented in at least one of my cases. Every instructor I studied adopted the Instructor role when they used their brief or debrief to connect the game to learning objectives or real-world engineering. Instructor-coordinated games such as the simulation games run by Belinay and Emily involved the instructors taking on a Playmaker role for the majority of gameplay. Andrew and Barry both spent the majority of their time as Guides, prompting students to reflect on their actions, and Victoria also took on a Guide role when she helped students troubleshoot their spreadsheets during her game. Finally, most instructors took on the role of a formative Evaluator either during the game, or in conducting the debrief after play. Accordingly, even at a more granular level, it appears that digital and non-digital game-based teaching are not far estranged, despite differences in the media of delivery. I therefore assert that comparisons between my results and findings from digital game-based learning research are reasonably comparable.

5.2. Prevalence of MUSIC components: Disagreements with prevailing theory

Literature on what motivates people to play games largely focuses on self-determined settings where individuals can choose whether or not to play a game. In these contexts, self-determination theory (Deci & Ryan, 2000) and related theories focusing on needs satisfaction, as well as flow theory (Csikszentmihalyi, 1990) are most commonly used to explain why people find games compelling (Zusho et al., 2014). Self-determination theory asserts that individuals develop intrinsic motivation to engage in gameplay because it satisfies the basic psychological needs to feel autonomous, competent, and socially related to others—in the MUSIC model, these needs most closely relate to empowerment, success, and caring. Flow theory asserts that people are motivated to continue to engage in a task when they enter a "flow state" and are completely absorbed in the task. Csikszentmihalyi (1990) observed that flow state was triggered when the difficulty of the task matched the skill level of the individual, resulting in an ideal level of challenge in which the individual was neither bored nor frustrated—in terms of the MUSIC model, flow theory maps well to the component of success. As Zusho et al. (2014) discussed, there is an implicit assumption in game-based learning literature that what makes games motivating in self-determined settings will translate to motivation to learn through game activities in the classroom, and this assumption has rarely been tested empirically.

My findings contradict the claim that what motivates people to play games in self-determined settings—primarily feelings of Empowerment and Success—is also what motivates students to engage in game-based learning activities. When discussing teaching practices that affected their motivation, students in my study emphasized Usefulness and Interest more often than they emphasized other MUSIC components, implying that these MUSIC components could be more critical than Empowerment or Success to consider when designing game-based instruction. In other words, engineering students were most motivated to learn (i.e., to engage with game-based learning activities) by game activities that they perceived as useful to their future, and in which game elements and teaching practices held their interest.

Interest theory is often discussed theoretically—but rarely empirically—in game-based learning literature as an important contributor to motivation (Plass et al., 2015; Zusho et al., 2014), and my study reinforces the need for empirical studies of interest and different ways interest can be fostered in game-based learning settings. Usefulness is less commonly discussed as a motivator in game-based learning, but my study demonstrates that students—at least in engineering—want classroom games to be useful for their academic and professional development. Therefore, Usefulness deserves more careful consideration as a motivator in game-based learning settings, either through use of the MUSIC model, value-centered theories such as expectancy-value theory (Wigfield & Eccles, 2000), or future time perspective theory (Simons et al., 2004)

5.3. Recommendations for practice and research

Guided by my observation that most game-based learning literature omitted instructional practices and did little to provide recommendations to instructors, I sought to use my dissertation as a means to offer new directions for game-based learning research and offer concrete suggestions for instructors planning to conduct game-based teaching in their classrooms. This section represents the culmination of both goals.

5.3.1. Practice recommendations for game-based teaching

My recommendations for game-based teaching practice are derived from two aspects of my data. First, differences between instructor expectations and student perceptions of how teaching practices affected student motivation revealed some aspects of game-based teaching that may need more attention from instructors. Second, student perceptions of game-based teaching practices that mattered most for a given MUSIC component could be used to extend existing four-phase models of game-based teaching with an eye toward instructor actions that bolster student motivation.

5.3.1.1. Using these recommendations: The importance of iteration

In the following sections, I present a plethora of game-based teaching recommendations that instructors can use to bolster student motivation. I anticipate that instructors already using games in their classrooms would be able to envision how these recommendations might supplement their existing practices, but that instructors new to game-based learning—or trying out a new game—may find my recommendations overwhelming. If you are a reader who would consider yourself among the latter, I recommend that you set most of my recommendations aside for the first iteration of your game activity, and revisit them when designing your second iteration of the activity. My instructor participants—especially Emily and Victoria—demonstrated that designing an appropriate game-based learning activity for a given classroom context occurs first and foremost through assessment, reflection, and iteration. Accordingly, I advise readers not to overthink the details of their first implementation of a game activity. Rather, if you have a game you would like to try in your classroom, implement it in the way you feel most comfortable, and build in opportunities for your students to give you feedback on their experience. These opportunities could include class-wide discussions, open-ended reflection worksheets or reports, or formal instruments for measuring student motivation—Jones (2017) offers several instruments based on the MUSIC Model. With student feedback to guide you, you will be better able to discern which of my recommendations would be good fits for your context.

5.3.1.2. Recommendations relative to key instructor-student differences

Differences between instructor expectations and student perceptions of how teaching practices affected student motivation reveal opportunities to improve game-based teaching practice by better aligning instructor practices with those that students found impactful. Given that students focused primarily on Usefulness and Interest, aligning teaching practices within these components has the greatest potential for broader impact.

In terms of Usefulness, instructors and students agreed that debriefing practices were most impactful, but while instructors emphasized reflective discussions, students emphasized both reflective discussions and hearing the instructor's perspective on the game's usefulness (Task Structure before/after the Game). Thus, as Jones (2009) recommended for the design of instructional activities in general, engineering instructors should be explicit about the usefulness of their game activities to students' future goals, including how the game relates to real-world engineering and future coursework. Making these connections explicit may be particularly important because instructors in my study tended to overestimate how apparent the usefulness of their activities was to students based on gameplay alone.

In terms of Interest, my findings reinforce the literature on teacher beliefs about student motivation asserting that instructors tend to underestimate the variety of ways that they can affect student motivation (e.g., Van Haneghan et al., 2015; Wiesman, 2012). Particularly, instructors focused on the design of their games (Task Structure of the Game) as influencing student Interest, and underestimated the impact of their teaching practices in other OPAL categories, compared to student responses. A handful of these OPAL categories can be leveraged as particularly salient opportunities to enhance student interest through game-based teaching practices.

First, the students cited instructor interactions—before, during, and after the game—as affecting their degree of interest. Particularly, my results suggest that instructors can affect students' situational interest by joking with students or otherwise making humorous comments during gameplay, or by setting goals for students to reach during gameplay when introducing the game, the latter of which may also positively affect student perceptions of Success. Moreover, instructors can connect to students' Individual Interest as engineers by connecting gameplay to real-world engineering in the debrief—which will also bolster student perceptions of Usefulness—and providing opportunities for students to share their experiences and approaches from gameplay.

Instructors can also influence student Interest through the establishment of compatible student groups and games that are well-paced—i.e., are perceived by students as neither too short nor too long. These criteria that groups be compatible and games be well-paced are subjective, and instructors should not expect to know how to meet them during their first implementation of a game. Rather, several instructor participants noted that most of their effective teaching strategies were developed over several iterations of game implementation and student feedback. As discussed previously, this cycle of designing and redesigning game-based learning activities across several iterations is a key element of existing high-level game-based teaching models (Alklind Taylor, 2014; Kangas et al., 2016).

Finally, competition was widely agreed upon by both instructors and students to be a positive affecter of student interest, and in that respect can be an easy element to introduce to a game to boost student motivation. These findings echo the results of a systematic review by Abdul Jabbar and Felicia (2015), who found that competition boosted student engagement across a range of game-based studies. However, I also found competition had mixed effects upon student perceptions of Success, and therefore competition must be implemented carefully to ensure students do not feel unsuccessful in learning if they lose.

On that note, while there were few differences related to Empowerment and Caring warranting discussion, there were a plethora of important differences related to Success. In interviews, instructors discussed many positive influences to Success with which students agreed, but rarely predicted the many negative influences to Success that students pointed out, suggesting greater care is needed in selecting teaching practices that may detract from student feelings of success. One such teaching practice with mixed reception from students in terms of Success was the inclusion of competition in games. Competition positively influenced success for students that won (or at least didn't place last), but made students feel less successful when they lost. One solution is to eliminate competition altogether—Andrew's random draw game demonstrated that games without competition can still be motivating—but this solution also eliminates the positive role of competition in keeping students interested in the game. Another solution involves ensuring that competition occurs between teams, rather than individuals. The effects of competition on learning have been explored in game-based literature, and Clark et al. (2016) reviewed this literature to determine that games involving team competition tended to be more beneficial for learning than games with individual competition. They speculated that better support for student motivation—particularly self-efficacy, a type of competence belief (Schunk & Pajares, 2005)—within groups may mediate this difference. My findings support their proposition, as students across multiple cases using teams noted that their teammates helped keep morale high.

Instructors could also adjust other elements of their games' design to reduce negative impacts on student perceptions of Success. For example, instructors could (1) reduce randomness outside of student control to reduce student frustration; (2) introduce milestones for more difficult games so students experience miniature victories along the way; (3) screen any preparatory work students complete prior to the game and provide appropriate feedback to students; and (4) incorporate practice rounds for games with high learning curves, as Emily did.

Instructors also underestimated the range of teaching practices that students stated as affecting their perceptions of success. The OPAL category where the difference between the two groups was greatest—Social Interactions—may also help assuage some of the negative effects on student perceptions of Success. Particularly, student interviewees described more positive beliefs about Success due to instructor encouragement and positivity, empathy in cases of negative emotions (especially if the game is designed to engender negative emotions, like Belinay's simulation game), and when instructors helped focus the experience on learning rather than game performance. The latter recommendation—encouraging students to focus on learning rather than performance—is critical advice to improve student motivation from the perspective of motivation theories focused on goals, such as goal orientation theory (Elliot, 2005), and can also help students feel more successful if they lose a competition by prompting them to focus instead on their takeaways from the experience.

5.3.1.3. A framework of game-based teaching to bolster student motivation

As discussed earlier in this chapter, I found that all of my cases followed the general four-phase cycle of game-based teaching synthesized at a high level by other authors working in this space (Alklind Taylor, 2014; Kangas et al., 2016)—instructors started by selecting or designing an appropriate game activity for their contexts, introduced the game to students in a briefing, allotted time for gameplay, and then brought students together for a debriefing to reflect on their gameplay experiences. While this high-level model has been replicated by at least two independent studies, the details of what kinds of activities are appropriate in each phase vary by author. Kangas et al. (2016) developed their model by synthesizing literature on optimizing student learning in game-based learning settings, and therefore focused on the variety of ways instructors can help students better connect the game to relevant course concepts in each phase.

Alklind Taylor (2014) was more concerned with capturing the range of roles her participants played when interacting with adult players in each phase, and thus her Coaching Cycle model emphasized game scenario design and means of interaction during gameplay, with the debrief acting as the phase in which learning objectives are emphasized. In both cases, learning is the student outcome of interest, and although the kinds of instructor actions each model encourages may affect student motivation, motivation is not a priority in either model's design.

Accordingly, a framework derived from my results would follow the same kind of four-phase model prototyped by Kangas et al. (2016) and Alklind Taylor (2014), and would provide specific actions instructors could take within each phase to bolster student motivation. Figure 6 exhibits my vision for such a framework, based on my findings. This framework is meant to supplement other models focused on student learning, not supersede them. All of the example recommendations displayed in Figure 6 are derived from my study, and many have already been discussed in greater length earlier in this chapter.

My framework offers many examples of recommendations instructors can implement to bolster student motivation, and I encourage readers to consider these recommendations as options, rather than requirements for a motivating experience. As Jones (2009) notes in his recommendations to improve student motivation based on the MUSIC Model, attempting to implement too many new ideas in a course at once is overwhelming, and instructors should instead strive to try one or two new ideas each iteration, keeping what works and discarding what does not. Accordingly, I have structured this framework to provide redundancies in terms of supporting each MUSIC Component across the difference phases of game-based teaching. For example, opportunities to improve student perceptions of a game activity's usefulness are highlights in both the briefing phase (e.g., "Explicate how your game relates to students' goals, such as its relationship to real-world work and future coursework") and the debriefing phase (e.g., "If your game is related to real-world problems, explain how professionals or experts would have gone about solving these problems.") I do not encourage instructors to feel pressure to implement all of these recommendations, but rather to try recommendations that seem to be good fits for their contexts, and to try to touch on each of the MUSIC components with at least one game-based teaching practice. The one exception is the very last recommendation—**solicit student feedback on their experience**—which I would assert is critical for any game-based learning activity to be successful in the long term.

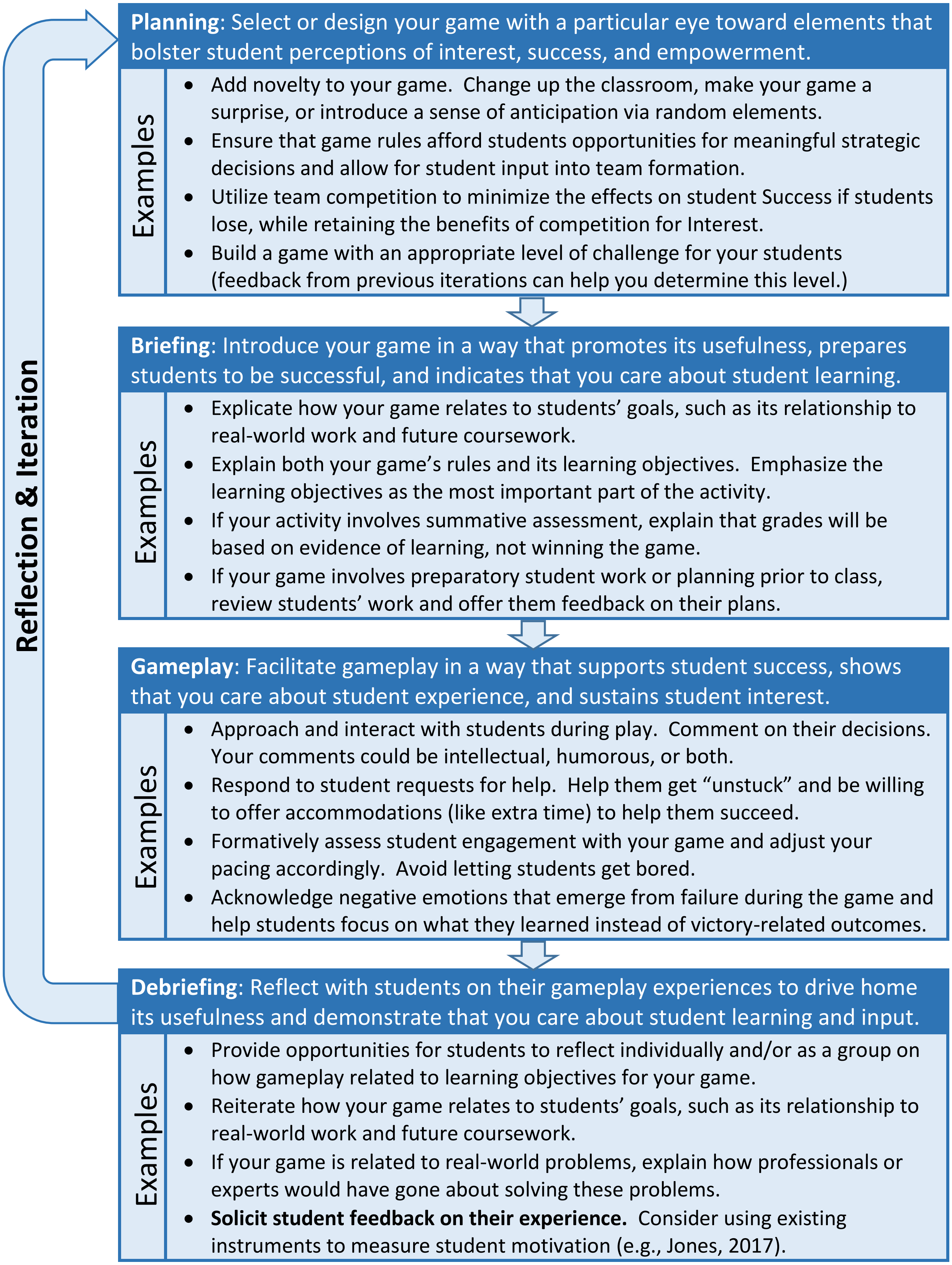

Figure 6: A four-phase framework of game-based teaching to bolster student motivation

5.3.1.4. Transferability of recommendations to non-engineering settings

Given that all of my cases took place in engineering classrooms, my recommendations apply most directly to instructors using game-based learning activities in engineering. However, I found little reason to suspect that the majority of my recommendations are inapplicable to other STEM disciplines, or other disciplines in general. Opportunities for student empowerment in strategy and team selection, means of bolstering student success or perceptions of success, elements that make games fun and interesting, and communication of caring are likely to be valued by students across a wide variety of disciplines. However, Usefulness may constitute an exception, as what students founds useful depended on their goals and aspirations. Because most of my cases took place in junior- and senior-level courses, the students I interviewed generally had well-defined career aspirations and appreciated when game-based learning activities helped them gain experience that would be relevant to their careers. Accordingly, my recommendations for usefulness emphasize the game's relevance to real-world work and problems, which may be unique to career-oriented disciplines like engineering.

5.3.2. Directions for future game-based learning research

As Eccles (2007) asserted in a chapter on the roles of families and schools on the development of student motivation, instructors play an important role in shaping students' motivation related to academic content. My study reinforces this finding in a game-based setting, as every aspect of instructor teaching practices—from the selection and introduction of their games to the debriefing procedures that synthesized student experience—were noted by students to affect their motivation through one or more MUSIC components. I therefore assert that game-based teaching practices are important variables to consider in future game-based research, especially research related to student motivation.

There are various possible directions future research on game-based teaching could take, but I believe it would be helpful to examine how game-based teaching practices vary with respect to different variables, and how student outcomes (e.g., learning and motivation) are affected accordingly. Some variables of interest include the learning objectives for the game, how the game is intended to contribute to learning (Morelock and Matusovich (2018) offer a typology of the ways games have contributed to learning in engineering), and academic disciplines (both within engineering and beyond). I also recommend a deeper exploration of how game-based teaching practices and student motivation differ by type of institution. I was able to provide some preliminary insight in my results—students at teaching institutions tended to place more emphasis on the instructor's brief and debrief as affecting Success, and on teaching-student interactions as affecting Caring—but my number of cases was too small to separate institutional differences in teaching practices from individual differences between cases.

Furthermore, new ways of operationalizing and categorizing game-based teaching practices would be an important contribution to the literature. I found OPAL an effective analysis framework for categorizing teaching practices in my study, but its application was not devoid of challenge. For example, Task Structure of the Game could potentially subsume many of the other OPAL categories, as rules relating to autonomy, recognition and feedback, and grouping are often embedded in a game's design; it took substantial effort to establish definitional bounds for Task Structure of the Game that did not conflict with other, more descriptive OPAL categories. Therefore, further iterations of OPAL operationalized in the game-based teaching space—or alternatively operationalizations of other frameworks—would contribute to further study of game-based teaching practices. Quantitative operationalizations would be particularly valuable in allowing game-based teaching research—presently a largely qualitative affair—to scale to larger studies more effectively.

I have also demonstrated the importance of studying student motivation in game-based learning settings using established frameworks of student motivation. My findings revealed that games and game-based teaching practices can affect student motivation in far more numerous ways than the ad hoc surveys used in many operationalizations of motivation in game-based learning literature (such as those captured by Wouters et al., 2013) would reveal. I recommend that future work in the game-based learning space continue to connect to established theories and frameworks of student motivation. In addition to the MUSIC Model, theories of particular interest are those that relate to Usefulness—such as expectancy-value theory (Wigfield & Eccles, 2000) or future time perspective theory (Simons et al., 2004)—and those that relate to interest—interest theory (Hidi & Renninger, 2006; Renninger & Hidi, 2011) most prominently, but other theories like expectancy-value theory are also relevant. The potential usefulness of interest theory in theory in particular in the game-based learning space has been echoed by several authors (e.g., Plass et al., 2015; Zusho et al., 2014).

Finally, continued study of non-digital games, alongside digital ones, is warranted. Non-digital games are often cheaper, more flexible, and require less technical expertise to implement compared to digital games (Institute of Play, 2014), and therefore comprise a useful medium for instructors that deserves more research to inform practice. Future research directly comparing the teaching practices, design, and outcomes of digital vs. non-digital games would be particularly helpful. As I discussed earlier, the teaching practices used in digital and non-digital games are similar at a high level, making game-based teaching work at least partially transferable between the two mediums. However, digital and non-digital games also feature some fundamental differences in their affordances and constraints, leading to differences in the kinds of ways they contribute to learning (Morelock & Matusovich, 2018). It would be useful to investigate how these differences affect student outcomes and variables related to game design and game-based teaching.

5.4. Conclusions

Through this study, I set out to determine how game-based teaching practices were perceived by instructors and students to affect student motivation across seven non-digital game-based learning activities. I intended to provide a model for a systematic study of game-based teaching practices using an established framework of student motivation, and to provide results that would be useful both to provide practice recommendations to instructors and to offer directions for future game-based teaching research. Accordingly, I used the MUSIC Model of Motivation to examine how different teaching practices affected student motivation differently across my seven cases. Prior to my study, game-based learning researchers had spent a great deal of effort detailing the learning benefits of digital games in relation to more traditional forms of instruction, had made strides in establishing how games theoretically should affect student motivation, and had begun to explore game-based teaching practices in terms of overall instructional design and instructor roles. However, the literature lacked detailed analyses of game-based teaching practices that could inform game-based instruction, featured few empirical studies of student motivation in game-based learning settings that utilized established theories of motivation, and backgrounded non-digital game-based learning applications. My work has begun to redress these gaps and advanced game-based learning as a learner-centered pedagogy by using the MUSIC Model to demonstrate that different game-based teaching practices affect student motivation differently, which informed several specific recommendations for game-based instruction and extended existing models of game-based teaching to address student motivation. My dissertation provides a model for qualitatively investigating teaching practices and student motivation in game-based learning settings, and I believe it will be helpful in providing direction for future game-based learning research.

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Appendix A: Pre-interview questions for instructors

1. [Icebreaker questions] How long have you been teaching this class? What inspired you to start using game-based activities?
2. What inspired you to start using games?
    a. How long have you been using this game in particular?
    b. How do games fit into your classes? (A fun tangent, an integral part of teaching, etc.)
    c. In what ways are you involved in gaming or gaming culture recreationally?
3. Tell me about the game-based activity(s) you'll be doing in class today.
    a. Walk me through how you intend to implement the activity, step-by-step.
    b. How did you decide to implement it this way?
    c. In terms of motivation, how do you anticipate students will respond to the activity?
        i. What leads you to that conclusion?
    d. How did student motivation play a role in your planning process?

[Shift] Thank you for your responses so far; you've been very helpful. I'd now like to ask questions about more specific aspects of your activity that you anticipate might affect students' motivation in different ways. [Questions henceforth were adapted from Jones (2017, p. 65).]

1. [Interest] How interested do you feel students will be in the activity(s)?
    a. What specific aspects do you believe will most capture student interest? Why?
2. [Usefulness] What aspects of the activity do you feel students will perceive as useful to them? Why?
    a. What about the activity will help students arrive at this understanding?
3. [Success] How will students know what is expected of them?
    a. How challenging do you think the activity(s) will be for students? Why?
    b. How will students know how well they are doing?
    c. What aspects of the activity do you feel encourage students to believe they can succeed...
        i. ...in the activity? Why?
        ii. ...as professionals? Why? *[This question is actually part of Usefulness, but it made the most sense to ask here.]*
4. [Caring] You've invested a lot of time into planning and using this activity, so you seem to care a lot about your students and their experience in this course. How do you anticipate that sense of caring showing up during the activity(s)?
5. [eMpowerment] What choices will students have about what they can do during the activity(s)?
    a. What else do you feel students will have meaningful control over?
6. [Time permitting] How large is your class?
    a. How do you think you would do this activity differently if you had a [larger / smaller] class?
7. That was my last question. Is there anything we haven't talked about that you would like to bring up?
8. Do you have any questions for me?

Appendix B: Interview questions for students

1. [Icebreaker question] Tell me a little bit about what you'd like to do once you graduate.

[Shift] To be respectful of your time, I want to jump straight into some questions about your perceptions the activity(s) you did in class.

2. [Icebreaker follow-up] How did the activity(s) you did in class relate to the goals you described earlier?
3. [Memory jog] As a refresher, would you mind walking me through what happened during the activity?
   a. What was your experience with the game? [In case participant just describes the rules]
4. [How motivated] First, how motivated were you to engage with the activity(s)?
5. [Why motivated] Second—and this is the main question—what are some things about the activity helped motivate (or demotivate) you to stay engaged with it?
   a. What are some things your professor did that helped motivate (or demotivate) you?
6. [eMpowerment] What choices did your professor allow you to have control over?
7. [Usefulness] What did you find useful about the activity(s)?
   a. How did your professor help make the activity feel useful to you?
   b. How did the activity(s) affect your feeling(s) that you could be successful in the "real world" (as a professional or in this class)?
8. [Success] What made you feel successful during the activity(s)?
   a. What did your professor do to help support your success?
9. [Interest] What did you find enjoyable or interesting about the activity(s)?
   a. How did the activity(s) relate to your personal interests?
   b. What did you professor do to help you become or stay interested in the activity(s)?
10. [Caring] What did your professor do to provide you with the impression that they cared whether you learned from the activity(s) and were successful during the activity(s)?

[The following questions are wrap-up questions to be asked in the last 5-10 minutes of the interview.]

11. What are some things your professor could have done differently to help motivate you during the activity?
12. That was my last question. Is there anything we haven't talked about that you would like to bring up?
13. Do you have any questions for me?

Appendix C: Class-Wide Student Survey Instrument

[All items are 6-point Likert Scale: Strongly Disagree, Disagree, Somewhat Disagree, Somewhat agree, Agree, Strongly Agree.]

Please rate the extent to which you agree or disagree with the following items.
There is no "right" or "wrong" interpretation of these items. If you are unsure how to interpret an item, please use your best judgment.

The term "**activity**" refers to the game you played in class today.

The term "**instructional methods**" refers to any game-related interactions you had with your professor. These could include one-on-one interactions, instructions your professor gave, or lectures that happened before, during, or after the game.

1. The activity held my attention.
2. I had the opportunity to decide for myself how to meet the activity goals.
3. In general, the activity was useful to me.
4. The instructor was available to answer my questions about the activity.
5. The activity was beneficial to me.
6. The instructional methods used in this activity held my attention.
7. I was confident that I could succeed in the activity.
8. I had the freedom to complete the activity my own way.
9. I enjoyed the instructional methods used in this activity.
10. I believed that I could be successful in meeting the academic challenges of the activity.
11. The instructional methods engaged me in the activity.
12. I had options in how to achieve the goals of the activity.
13. I enjoyed completing the activity.
14. I was capable of performing well in this activity.
15. The activity was interesting to me.
16. The instructor was willing to assist me if I needed help in the activity.
17. I had control over how I learned the knowledge needed to succeed in the activity.
18. Throughout the activity, I believed that I could be successful in the activity.
19. I found the activity to be relevant to my future.
20. The instructor cared about how well I did in this activity.
21. I will be able to use the knowledge I gained in this activity.
22. The instructor was respectful of me.
23. The knowledge I gained in this activity is important for my future.
24. The instructor was friendly.
25. I believe that the instructor cared about my feelings.
26. I had flexibility in what I was allowed to do in the activity

Appendix D: Case Summaries

Barry Case Summary

Case Characteristics

Month Collected	March 2018
Institution Type	Large, public, research-focused
Approx. Class Size	250 students
Academic Level	First-year students
Engineering Discipline	General engineering
Classroom Setting	Large auditorium, fixed seating
Approx. Length of Class	60 minutes
Approx. Length of Game	20 minutes
Help Available	3 co-teachers, 1 undergraduate TA, 1 educational researcher
Student Interviewees	4

Game Description

Barry's game was an engineering ethics card game, styled after the popular commercial games Apples to Apples, and its raunchier counterpart Cards Against Humanity. Barry designed the game alongside an educational researcher as a means of introducing engineering ethics topics to students in a fun and engaging way, and had used it once the previous academic year. In the game, one player acts as a "judge" and draws a prompt card from a deck of prompt cards. The prompt card contains a statement with one or more blanks that other players must fill in. For example, a prompt card might read "It was a normal day on the job, until my boss started _________." The other players, who each have a hand of ten randomly drawn response cards from a separate deck, select card(s) from their hands to fill in the blanks. The prompt card is then read out loud by the judge, who fills in the blank with each submission. The judge selects a submitted card as the winner, based on any criteria he or she sees fit—the funniest cards or the cards that make the most sense in context are common criteria. That player gets a point, and a new player becomes the judge. This gameplay loop repeated until Barry announced the end of the game. Barry hoped that by playing the game, students would be exposed to novel engineering ethics-related scenarios and consider what they would do given the context of these scenarios, and that judges would think critically about why they picked certain cards as winners.

A slightly altered version of this game was used by Andrew in one of his cases.

Observed Class Summary

After addressing some housekeeping items and typical class start activities, Barry begins the game briefing process by introducing the topic of engineering ethics. He asks students why they think engineering ethics is an important topic, and how they would go about selecting the "right" course of action in an ethically challenging scenario. For each round of questions to his students, Barry waits patiently for at least three responses before moving on, and pauses to affirm each student's response. He then asks students to form groups of 3 or 4 based on proximity, and to select one person from each group to come to the front of the room to pick up the game's cards. Barry went on to explain the game, asking how much of the class had played Cards Against

Humanity, and likening the rules to that game. He briefly explained how cards should be played, asked groups to ensure that everyone gets a chance to be a judge at least once, and stated that the game would be played for about 20 minutes. He then turned students loose and gameplay began.

The four instructors, TA, and educational researcher then began walking around the room and interacting with and/or observing student groups. According to students, different instructors engaged with them at various levels of depth during the game, but Barry (who was the focus of my observation) took a relatively hands-off approach to facilitation. He spent most of his time during gameplay assessing the room for levels of engagement—via the amount of "buzz" around the game—and chatting with other instructors to learn their assessments of the game as gameplay continued. Occasionally Barry would approach a group, say hello, and state that he was just observing and trying to see what they were thinking. He often made witty or funny remarks about card combinations, and joined in to laugh when students found something funny. He and other instructors also noted several students deviating from instructions—some searched through the decks for good answers, some played in groups of two or solo—but no disciplinary action was taken. When one instructor noticed that one group had stopped playing once everyone got to judge once, Barry made an announcement to the class that they should keep playing until the end. After 20 minutes had passed, Barry confirmed with other facilitators that the energy in the room was starting to die down, and then announced that groups should begin to wrap up their final rounds. He then began a debriefing process.

Similar to his briefing process, Barry's debrief consisted of him asking for student input, waiting for and affirming student responses, and then offering his perspective. Particularly, he asked students how they went about selecting winning combinations, how their behaviors during the game would compare to their behaviors in real life, and what they through the purpose of the activity was. He concluded the discussion by explaining his purpose in using the game (described above in the game's description) and asked students to reflect more deeply on their choices prior to the next class—e.g., why they considered certain combinations "funnier" or "more awful" or "more wrong" than others. Finally, he asked students to pull out their laptops to answer an online, open-ended reflection survey featuring the same kinds of questions asked in the class discussion, and to answer a survey to provide

This class was the first part of a two-class series using the engineering ethics card game, and Barry expected the second play session to involve more serious reflection on the game's relationship to real-world engineering. He revealed this to students immediately prior to ending class, and again encouraged students to reflect on their experiences between classes.

MUSIC Summary

Overall, Barry and his students agreed that **Interest** was the most influence MUSIC component in terms of student motivation, with all students noting that the game was fun and relatable. However, the **Usefulness** of the game was largely lost on student interviewees, all of whom had takeaways that misaligned with Barry's intended takeaways, and two of whom stated that they did not find the game or debrief useful—though it is worth noting that Barry expected most of the game's Usefulness to become more evident in the second play session, which was not part of my study.

Regarding **Empowerment**, Barry and students agreed that students had the freedom to play the game as they wished, and some students also appreciated the freedom to select their own teams.

In terms of **Usefulness**, while Barry stated in his interview that the main purpose of the activity was to help students realize the importance of context in ethical decision-making, student interviewee takeaways focused on identifying and avoiding unethical situations. Moreover, while two students found that their own self-reflection during gameplay helped the activity feel useful, the other two stated that they found the game and discussion too shallow to be useful.

With respect to **Success**, students had little agreement regarding what helped them feel successful during the game, other than its similarity to Cards Against Humanity—which Barry anticipated. Some students expressed that they did not believe Success was an important MUSIC component in the context of this game.

For **Interest**, there was strong agreement among student interviewees on the elements of the game's design that held student interest: (1) the cards were fun, relatable, and led to funny combinations; (2) they liked Cards Against Humanity, and this game was similar; and (3) they were empowered to judge response cards based on whatever criteria they wanted. Barry predicted most of these factors, and both Barry and students felt most strongly about interest as an influencer of student motivation in this game activity.

For **Caring**, Barry felt instructor enthusiasm would most demonstrate that the instructional team cared about student experience. Students, on the other hand, focused more on the fact that the instructors seemed interested in hearing student feedback about the game, and that the reflection activities showed the instructors cared about their learning.

Andrew (Card Game) Case Summary

Case Characteristics

Month Collected	September 2017
Institution Type	Small, private, teaching-focused
Approx. Class Size	60 students
Academic Level	Seniors
Engineering Discipline	Chemical engineering
Classroom Setting	Small auditorium, fixed seating
Approx. Length of Class	60 minutes
Approx. Length of Game	25 minutes
Help Available	1 co-teacher
Student Interviewees	1

Game Description

Andrew's card game was an engineering ethics card game, styled after the popular commercial games Apples to Apples, and its raunchier counterpart Cards Against Humanity. Andrew obtained the game from one of his colleagues, who also participated in this study under the pseudonym Barry. In the game, one player acts as a "judge" and draws a prompt card from a deck of prompt cards. The prompt card contains a statement with one or more blanks that other players must fill in. For example, a prompt card might read "It was a normal day on the job, until my boss started _________." The other players, who each have a hand of five to ten randomly drawn response cards from a separate deck, select card(s) from their hands to fill in the blanks. The prompt card is then read out loud by the judge, who fills in the blank with each submission. The judge selects a submitted card as the winner, based on any criteria he or she sees fit—the funniest cards or the cards that make the most sense in context are common criteria. That player gets a point, and a new player becomes the judge. This gameplay loop repeated until Andrew announced the end of the game. Andrew's goal in using the game was to get students engaging with ethics-related scenarios as an introduction to a larger module on engineering ethics, and also to provide an icebreaker activity for new student project groups.

Observed Class Summary

Andrew and his co-instructor began by handing out paper bags containing the decks of cards for the game as students came into the room, instructing students to find their new group members, of which they had been informed prior to class. When class officially started, after a few housekeeping items, Andrew asked students to open their bags and shuffle the decks within. They then initiated a short briefing process to introduce the game. They asked students whether they had played Cards Against Humanity or Apples to Apples, and likened this game to those popular commercial games. He explained that the purpose of the game was to learn a little bit about ethical boundaries and to learn more about fellow groupmates. He then briefly explained the game's rules, including how judging works, how to respond to prompt cards, and how scoring works. Andrew ended the briefing by projecting a few reflection questions he wanted students to think about during play, such as why they chose to play certain cards. He then projected the game rules again, and left them displayed for the duration of the game.

During the game, Andrew (who was the focus of my observation) walked around the room and interacted with student groups in a variety of ways. A few teams had questions about the game's rules, which Andrew promptly answered. As he approached groups in the middle of judging, he would ask what the prompt card was, and follow up with some students, "Why did you pick that [response] card?" He offered praise for responses that he thought were particularly good for a prompt card, laughed along with students when they found a combination funny, and celebrated with students when they were excited about something. If students didn't understand a card—some cards referenced theories and history of ethical thinking—Andrew explained them. At one point, a team accidentally spilled their cards onto the floor, and Andrew helped them pick the cards up. After completing one full patrol of the classroom, Andrew announced to the class a reminder that they should be taking note of any particularly interesting card combinations. He then continued to patrol the room, this time acting more as a silent observer of each team. After 25 minutes, he announced that the game was ending and that students should wrap up their last round of judging.

Andrew's debrief was conducted in two phases, with a short break between them. The first phase was a class discussion. Andrew asked students why they picked the cards they did, and occasionally followed up on student responses—for example, when a student said they picked the "least appropriate" combination, Andrew asked, "How did you know what was least appropriate?" He asked students to offer examples of interesting combinations, and in what contexts students played a particular response card, "Doing the right thing." Finally, he asked students why they thought the instructors had them play this game, and students generally parroted the reasons Andrew stated during the game's briefing. Andrew concluded this phase of the debrief by asking if they (the instructors) should continue using this game in future semesters, to which the class responded positively.

The second phase of the debrief was an introductory lecture on engineering ethics. The lecture discussed differences between ethics and morality, basic tenets of ethics in the context of research and engineering practice, and codes of ethics applicable to chemical engineers. Occasionally they would cover a technical term featured on one of the response cards, and would call attention to that fact.

MUSIC Summary

An important limitation of this case was the fact that only one student volunteered to participate as an interviewee, and this MUSIC summary should be interpreted with that limitation in mind. Generally, Andrew and the student interviewee agreed that **Interest** was an important contributor to student motivation, though the student also emphasized **Usefulness** as a major motivator for her, and valued the more down-to-earth aspects of the activity and debrief more than Andrew anticipated.

Regarding **Empowerment**, both Andrew and the student agreed that the game had a fairly rigid ruleset, but that students had control over which cards they played and how they went about judging.

In terms of **Usefulness**, Andrew expected that students would derive most of the game's usefulness from the debrief. While the student agreed that the debrief was helpful, she also appreciated card combinations during the game that introduced ethics scenarios she hadn't considered before, and appreciated Andrew's reflective prompting during play.

With respect to **Success**, Andrew intended the game to be easy to play and to include a playful, minimal level of competition, where knowing one's opponents was helpful to winning. The student agreed that knowledge of opponents was helpful, but she did not know hers very well. Additionally, during the discussion, she did not feel confident enough in her ethics knowledge to feel comfortable contributing.

Andrew considered **Interest** to be the primary motivation-related benefit of the game, in terms of the game's similarity to popular commercial games, the potential for card combinations to be both funny and interesting, and student empowerment to judge as they saw fit. The student stated that she liked the competitive aspects of the game and its similarity to Cards Against Humanity, but placed a greater emphasis on the game's relationship to the real world and her professional interests. She was frustrated that her classmates didn't take the game very seriously.

For **Caring**, Andrew emphasized his choice to use a game and his attention to students during the game as demonstrating that he cared about student learning. The student instead discussed how Andrew used the debrief to connect the game to learning objectives as evidence that he cared about student learning.

Andrew (Random Draw Game) Case Summary

Case Characteristics

Month Collected	October 2017
Institution Type	Small, private, teaching-focused
Approx. Class Size	60 students
Academic Level	Seniors
Engineering Discipline	Chemical engineering
Classroom Setting	Small auditorium, fixed seating
Approx. Length of Class	60 minutes
Approx. Length of Game	30 minutes
Help Available	1 co-teacher
Student Interviewees	2

Game Description

Andrew's random draw game was a random draw game meant to serve as an analogy for investing in preventative safety measures in chemical plants. Andrew obtained the game from a guest speaker who used the game as part of a larger chemical process safety module two years prior in Andrew's course. This was Andrew's second time running the game. In the game, teams of students drew beads randomly from a paper bag containing 100 beads. These beads represented events during a chemical plant's production. Most beads were green, signifying a successful round of production with no incidents, and earned the team a small profit. However, each bag contained a small amount of blue, yellow, and red beads, each signifying an incident with various levels of severity—ranging from a minor loss of profit to the plant exploding. Each bag was labeled and had a different distributions of beads known to the instructors but unknown to students. After each round, the team replaced the bead into the bag and drew again for the next round. During the game, students could purchase "protections" of each incident color, which negated the negative effects if a bead of that color was drawn, and was then discarded and could be purchased again. The goal of the game was to play 100 rounds (draw 100 beads) and still emerge with a positive profit and an unexploded plant. The game continued until all teams had played through (to a victory or loss) at least once. Andrew's goal for the game was to demonstrate the importance of process safety measures and give students an opportunity to practice safety-related decision making in a game setting.

Observed Class Summary

Andrew's co-instructor led the briefing and debriefing processes for this game. However, Andrew was still my instructor interviewee and my primary focus of observation during the game.

As students came into the class, Andrew and his co-instructor told them to sit in their project groups—the same groups formed for Andrew's other case. Once students were seated, Andrew's co-instructor talked through a slide that was a brief overview of chemical process safety, and encouraged students to remember another process safety activity they did in a previous class. He then briefly described the game and instructed a representative from each group to grab a set of materials from the front. Each set of materials contained a bag of beads, a sheet of paper describing the game rules, and a sheet of paper to keep track of progress and profits throughout the game. Andrew then explained the rules of the games, demonstrating what a round looked like and how protections worked, and noting key things to which to pay attention to each round. Andrew also specified what each color of bead represented in terms of real-life incidents in chemical plants. The instructors then let students begin.

The roles Andrew and his co-instructor played during gameplay change substantially from start to finish. Near the beginning of the game, they spent most of their time noting decisions that students were making and clarifying any rules about which students were unclear. They occasionally asked students why they bought certain protections or what their overall strategies were. They occasionally gave evaluative feedback to students—e.g., "That sounds like a good plan." However, approximately halfway through gameplay, several groups in sequence drew red beads with no red protections, causing their plants to explode, thus losing the game. The instructors had several spare bags at the front of the room, and offered to give them a new bag to play again. Some groups took the offer immediately, some needed substantial encouragement from the instructors, and some chose not to play again at all. Regardless of their decisions, when a group finished playing, Andrew or his co-instructor would cross-reference their bag to determine the bag's distribution of beads, and disclose this distribution to students. Andrew sometimes followed up with questions like, "Does knowing the contents [of the bag] make you regret your purchases?" The rest of the instructors' facilitation time was taken up by this disclosure process. After 25 minutes, Andrew announced to the class that they should wrap their games up and bring their materials back to the front of the classroom. He put up a list of discussion questions and asked groups that had already finished to begin discussing amongst themselves.

Andrew's co-instructor then led a debriefing discussion, going through the list of questions that Andrew put on display. He started with a question about the ethicality of operating a plant without proper protections in place, asking students to draw from their game experience. He followed up by asking how knowing the distribution of beads in a bag would have affected decision-making, and asked how a dangerous process' value to society affected the ethicality of performing it. Students were quick to blurt out answers, and most pointed out major differences between how they would perform in the game setting as opposed to reality. In cases where students offered few responses, Andrew would often ask for counterpoints. Andrew ended by offering his perspective on some of the questions, based on chemical engineering codes of ethics. Andrew's co-instructor asked if students liked the game, which was met with a lukewarm response.

MUSIC Summary

An important limitation of this case was the fact that only two students volunteered to participate as an interviewee, and this MUSIC summary should be interpreted with that limitation in mind. Generally, Andrew predicted most students' perceptions of what affected their motivation, but both students' experiences were significantly hampered by bad luck and subsequently running out of money within the game.

Regarding **Empowerment**, both Andrew and the students agreed that the game had a fairly rigid ruleset, but that students had control over the roles they played (e.g., drawing from the bag, updating the tracking sheet) and over what protection to buy. However, one student noted that most empowerment during the game—buying protections—was dependent on having money to spend, suggesting that running out of money was tantamount to being helpless.

In terms of **Usefulness**, Andrew expected that some students would “get it” while playing the game, some would find the debrief most useful, and others would dismiss the game as not useful. Despite having poor luck during the game, both interviewed students found the game useful—as Andrew predicted, one student found the relationships of the game to real-life events to be useful, and the other appreciated hearing about the game’s usefulness during the debrief.

With respect to **Success**, Andrew intended the game to a low level of challenge, with clearly explained rules and the ability to mitigate randomness through purchasing protections. However, while both students agreed that the rules were well-explained, they both ran out of money to purchase protections, and found the game intractable at that point. One student’s team, after losing once, “bought” a bag from another team that won, along with information about its contents. Knowing that information helped her team have a more successful second playthrough.

For **Interest**, Andrew expected students to find the game fun and lighthearted, but had few expectations about what students would find interesting about the game other than the novelty of each draw and its parallels to the real world. The two students thought the game was fun and related to their professional interests, enjoyed the novelty of each draw, and also commented on the instructor’s enthusiasm for the game. One student commented that 100 rounds felt like too much, and eventually led to boredom.

For **Caring**, Andrew emphasized his choice to use a game and his attention to students during the game as demonstrating that he cared about student learning. Caring was more important to one of the student interviewees than the other, and this interviewee appreciated that instructors offered some strategic advice to her team, connected the game to learning objectives, and asked for student input during the debrief.

Emily Case Summary

Case Characteristics

Month Collected	December 2017
Institution Type	Large, public, research-focused
Approx. Class Size	60 students (game), 80 students (debrief class)
Academic Level	Seniors
Engineering Discipline	Industrial Engineering
Classroom Setting	Hotel Conference Room, Flexible Seating (game); Wide classroom, fixed tables, flexible seating (debrief class)
Approx. Length of Class	5 hours (game), 75 minutes (debrief class)
Approx. Length of Game	5 hours (game), 15 minutes (debrief)
Help Available	4 graduate TAs (game), N/A (debrief)
Student Interviewees	4

Game Description

Emily's game was an five-hour-long manufacturing simulation game in which teams of ten students formed a manufacturing "company" to plan and execute a production plan over a simulated nine-month period given a known distribution of random customer demand. Emily discovered the game at an industrial engineering conference approximately 20 years ago, and decided to implement it as a capstone experience in her production planning course, helping students synthesize and apply the concepts and tools they learned throughout the course, while also giving them experience in working in large teams. She gradually adapted the game from its original form to fit her classroom context, and it has since become a permanent fixture in the course curriculum, even when Emily is not teaching it. This was Emily's thirteenth time implementing the game. The game's original form was published by Ammar and Wright (1999) under the title, *ABC's Manufacturing Game*.

Teams were formed semi-randomly, with students specifying other students with whom they wished to be on a team, and Emily assigning teams in such a way that each student was matched with at least one person they selected, where possible. In the game, each team was charged with working together to use an instructor-provided random distribution of customer demand—along with production planning and inventory management concepts learned throughout the production planning course—to construct and execute a complete production plan that maximizes profits based on customer demand and production costs. Students were given a three-week period in which to plan their production, during which they were provided a document describing how the game works, the anticipated customer demand distribution, and potential roadblocks they might encounter. Emily offered extra office hours during this time. A week before the game, students submitted their initial plans, and Emily provided each team with feedback prior to the game. During the game, six teams competed by executing their plans over a nine-period window during a single five-hour play session, with each period lasting an average of 20 minutes. In each period, students would order a certain number of parts—provided to them as slips of paper by the TAs—and would have to combine these parts in particular ways to create products that would hopefully meet but not exceed customer demand. Teams submitted their products to a TA (serving the role of the customer) who would verify they were properly constructed. Each period ended with a reveal of customer demand for each type of product, and the leaderboard of each team's profits—which was managed and verified by the TAs—was updated. Students then had to adjust their plans given the results of customer demand, along with other unforeseen events like workforce illness or defective parts. At the end of the game, students congregated around the leaderboard to find out who won. The game included a break midway with food catered by the hotel in which the game took place.

Each of the ten students in a team took a well-defined role within their "company," and was responsible for a particular part of planning or execution. For example, a student who took the role as a company's CFO was responsible for the majority of the financial planning process, while a student who took the role of a manufacturing worker was responsible for ensuring that parts were constructed during the game according to the company's ever-adapting plans.

The winner of the game received some points of extra credit on the final exam. Two weeks after the game was over, each team submitted a report reflecting on their results, experience, and lessons learned. This report was graded by Emily and comprised 20% of students' final grades.

Observed Class Summary

In total, Emily's course had 160 students across two sections of 80 students each. Three distinct game sessions took place across three nights, with each game session including 50-60 students. The game's debrief took place during regular class time approximately 1 week after the game sessions. I observed the second game session and the debrief across both class sections.

Despite students having several weeks to become familiar with the premise of the game, Emily took steps to brief students at the beginning of the game session to help the experience run smoothly. She began by asking the two highest ranking roles in each company (the president and CFO) to arrive 30 minutes early, and made sure they started with all the initial materials they needed for their plans. In cases where teams changed their plans since Emily saw them in student submissions, she accommodated any differences. In other cases where she did not understand a team's plan from their submission, she asked the team to walk her through the plan during this time. Emily also answered students' logistical questions about the game. Once the questions of this subset of students had been addressed, Emily invited other students into the room and began explaining the game. She explained the rules of the game and the role of each of the four TAs in the room. She also announced that the first period would go much more slowly than other periods to acclimate students to the game, and reminded students that the purpose of the activity was to learn, and thus it was okay to not win. The whole briefing process took 45 minutes. At this point, students were eager to start playing, so she turned them loose, and the game began.

As Emily expected, the first round of the game was chaotic, and Emily played multiple roles during this time. She responded to students' logistical questions, tried to comfort students that seemed overwhelmed, noted common mistakes and addressed them to the room, coordinated with her TAs, encouraged students to maintain a good pace, and offered praise to teams that were progressing well. She did not freely give strategic advice to teams, but also did not shy away from answering students' questions about how certain strategies might affect them down the line. After approximately 30 minutes, she encouraged teams to finish producing for the round, and gave each team a “Ready” sign they could display to communicate that they were finished. When one team lagged behind the rest, Emily decided to delay the game for them, to “give them time to settle in,” as she conferred to me. Once that team finished, Emily revealed the demand from Period 1 and started Period 2, announcing that students should aim to finish within 15 minutes. She also comforted teams that were distraught about not meeting demand.

Students became more comfortable with the game and asked fewer questions in future rounds, most of which were answered by TAs rather than Emily. Emily spent most of her time managing time, resolving differences between TA and student calculations of teams’ profits, and occasionally answering rules questions from students. In terms of time management, Emily struggled to get teams to finish on time, and after consulting with the TAs, introduced a monetary penalty for taking extra time, which one team fairly consistently took. In later rounds, the vast majority of Emily’s time was consumed reconciling differences in profit calculation, which led to a couple of significant changes in the leaderboard. After the game was over, students gathered around the leaderboard. Emily again reminded students that it was okay to not win, revealed the winner, and led the class in applause. She then released them to go home for the evening.

About a week later, Emily led a debriefing discussion at the beginning of her two class sections. Both debriefing sessions proceeded in the same manner. Prior to class, Emily had contacted specific teams—including teams that won—and asked for volunteers to participate in the discussion. When class started, Emily congratulated the teams that won and displayed the planning documents of the teams that volunteered. She then asked a representative of those teams to explain their overall strategy and experience for the class. Emily then pointed out a few other things about the team’s behavior that she thought were productive. She also publicly recognized some teams that didn’t win, but still showed desirable performance—for example, she commended one team for encouraging positivity and high morale throughout the activity, even when they weren’t winning. After hearing from at least one team from each of the three game sessions, she ended the debrief and continued with non-game-related class content.

MUSIC Summary

Generally speaking, Emily’s expectations of what teaching practices would affect student motivation aligned well with student perspectives, but she underestimated the range of practices that students stated as affecting their motivation. From a student perspective, **Caring** played a greater role in student motivation than it seemed to play for other cases.

Regarding **Empowerment**, Emily and her students agreed that students had the freedom to form their own strategies and play as they wished, and also had input into their choice of team. Students specified that they also got to pick their roles within their teams, and that the randomness of consumer demand was one of the few major factors of the game over which they had no control.

Emily considered **Usefulness** to be the most important MUSIC component for the game, and students also emphasized the game’s usefulness. Emily stated that the game was meant to help students integrate course topics, give them experience in working in large teams, and also experience a simulated manufacturing environment with reasonable fidelity for real-like production planning work. Students agreed that the realism of the game was useful, but also placed a higher premium on the gameplay experience, especially as it related to working in teams and dealing with uncertainty. Moreover, some students in more labor-intensive roles felt that their roles unnecessarily restricted their learning opportunities. Finally, some students found the fact that the activity was graded, and that extra credit was offered as a prize, made the activity inherently useful.

With respect to **Success**, Emily anticipated that her communication of the game's rules and objectives, both in the documentation of the game and in her briefing before the game, would boost student success. She also stated that students have the freedom to define their own success, based on things like the leaderboard and how quickly they can finish a round. Some students did indeed make their own definitions of success, but when it came to other teaching practices that facilitated success, students focused more on Emily's actions during the game. These actions included making accommodations for students, checking on groups and answering questions, maintaining a positive atmosphere, and maintaining the leaderboard.

For **Interest**, Emily expected that student competition played an important role, even though she herself was ambivalent about the benefits of including competition in the game. She also anticipated that working in a team, playing the game in an off-campus setting, and having friendly facilitators would bolster student interest. Students agreed on most of these points, but cited a far greater range of factors as affecting their interest, including the randomness and anticipation of demand, the relationship of game content to their professional interests, and Emily's enthusiasm.

For **Caring**, Emily stated that her offering of extra office hours and the friendliness of her and her TAs would demonstrate caring to some degree. Students, on the other hand, felt very strongly that Emily cared about their learning and experience during the game, and cited a large range of teaching practices that demonstrated this caring. These practices included asking for student feedback on the game; being supportive, accommodating, and enthusiastic; giving students plenty of attention during play; and including structured reflection activities.

Belinay Case Summary

Case Characteristics

Month Collected	March 2018
Institution Type	Large, public, research-focused
Approx. Class Size	25 students
Academic Level	Juniors and Seniors
Engineering Discipline	Industrial Engineering
Classroom Setting	Small classroom, flexible seating
Approx. Length of Class	75 minutes
Approx. Length of Game	35 minutes
Help Available	1 graduate TA
Student Interviewees	3

Game Description

Belinay's game was a longstanding supply chain simulation game known as *The Beer Game*, which was developed at MIT during the late 50's and early 60's (Martinez-Moyano et al., 2005). Belinay learned about the game from her doctoral advisor, and has implemented it in her supply chain management course since she began teaching it several years ago. In the game, students are randomly assigned to teams of four, with each person representing a different actor in a beer supply chain—beer manufacturers supply beer distributors, who supply beer retailers, who ultimately supply beer retailers, who sell beer to simulated customers based on a simulated demand. The goal of the game is to maximize the profit of the supply chain across 35 periods. However, the catch is that students cannot communicate with one another through any means other than placing orders, true demand information is only available to the retailer role, and each order has a delay of one period to reach the next person up the supply chain, and two periods for the product to physically travel back down the supply chain. The game starts smoothly, with a steady customer demand of four beer cases per period. Then, a few periods into the game, that demand jumps to 8 cases per period. Retailers increase their orders accordingly, but get desperate as the orders don't come in three weeks as expected—as their suppliers also have delays further up the supply chain. The retailer then usually starts "panic ordering" by increasing their order quantity each period to overcompensate for their lack of inventory, and this panic ordering effect cascades all the way up the chain. By the end of the game, each student ended up with far more inventory they could possibly sell. This behavior is called the "bullwhip effect" in supply chain engineering, and is an intentional outcome of the game, as the purpose of the game is to demonstrate the importance of communication and collaboration across successful supply chains. In addition to learning first-hand about the bullwhip effect, Belinay hoped that students would recognize these takeaways through playing the game.

Belinay used an online, digital version of *The Beer Game*. How students interacted with the online game fit well with contemporary non-digital implementations of *The Beer Game* (Martinez-Moyano et al., 2005), with some additional affordances that helped move the game activity forward smoothly and quickly. These affordances included assigning students to supply chains anonymously to ensure communication among students was infeasible, automatically producing graphs of supply chain performance to inform the debriefing process, and providing the option of AI to take roles within some supply chains in case the number of students in the class was not evenly divisible by four.

Observed Class Summary

Belinay began by briefing the overall structure of the game. She explained the roles that each student would take, gave tangible examples of how the delays in moving order and products through the supply chain would manifest in-game, and discussed the cost structure so that students could strategic decisions to maximize profit (e.g., it cost twice as much to miss an order as it did to hold extra inventory.) She even offered strategic advice by emphasizing that students should keep in mind that delays were applicable throughout their supply chains, not just for their orders alone. She then walked students step-by-step through what a period of the game would look like, important elements of the computer interface with which they would be interacting, and finally encouraged them to think about the supply chain concepts they learned in the course. Then, she gave students the instructions they needed to log into the online game and be randomly assigned to a supply chain team. Two teams only ended up with three students out of the four teams, and so Belinay assigned an AI to fill in the missing role on both these teams.

As the game started, some students had issues getting and staying connected to the online system, which Belinay's TA helped troubleshoot. Projected at the front of the classroom was the instructor interface for the game, which showed Belinay and her students who had and hadn't submitted their orders in the current period—students did not know who was on their team, but a student did know, for example, that they were the Manufacturer for Team 4. Belinay did not impose a time limit for the first few periods, instead wanting to give students an opportunity to get used to the flow of the game. She waited for all students to input orders before moving to the next period, but nonetheless spent the majority of her time encouraging students to make their decisions more quickly, because she stated that in real life there is often a time pressure involved with making decisions. She pushed students to act faster in each period, suggesting she would move to a "time pressure mode" if they did not, which would automatically progress periods every 30 seconds, regardless of who did and did not place orders. Students did slowly pick up the pace. During Period 12 (a few periods after the scripted demand increase), she gave students extra time to re-evaluate their strategies. Around this time, noise in the classroom picked up as students commiserated about not receiving orders. After Period 15, Belinay switched to the "time pressure mode" to simulate real-world time pressure in decision-making, and to ensure she could finish the activity on time. At first, a few students did not submit orders on time, but gradually the class got used to the change. After 35 periods, Belinay ended the game.

After the game, Belinay began a short debrief by displaying tables and graphs showing each supply chain's performance—students also had their own supply chain's table and graph on their laptops. She asked the teams with the best and worst performance to identify themselves; she congratulated the winners and called attention to the mistakes of the team with the poorest performance, but also explained that the bullwhip effect is a systemic phenomenon, and that no individual should feel they are to blame. She then asked students to identify factors that they believed contributed to the bullwhip effect. As students responded, the TA took notes on a whiteboard, while Belinay probed student further about their experiences and asked for examples of different experiences. Belinay ended the debrief by using the graphs to illustrate exactly what the bullwhip effect looks like in practice for each actor in the supply chain, and soliciting student suggestions for how the bullwhip effect could be addressed—as the TA continued to take notes.

MUSIC Summary

A limitation of this case was the fact that only three students participated as interviewees, and no student was from the winning team nor the team with the poorest performance. This MUSIC summary should be interpreted with that limitation in mind. Generally, Belinay and her students agreed that the game most poignantly impacted student motivation via Usefulness, but the teaching practices perceived to effect that impact differed.

Belinay viewed **Empowerment** as a key influencer of other MUSIC components for this game, as the goal of the game was to demonstrate that one does not have enough control of a supply chain on one's own to be successful without communicating with others in the chain. Thus she restricted student empowerment to the issuance of orders by limiting students' ability to communicate. Students agreed with Belinay's perspective, but viewed themselves as being empowered not only in the manipulation of parameters, but also in the strategies they chose to employ. Though few students emphasized reliance on other students as disempowering, they all felt the frustration that stemmed from that reliance coupled with a lack of communication.

In terms of **Usefulness**, Belinay expected that the frustration resulting from disempowerment during the game would lead students to recognize the negative effects of a lack of communication on supply chains. She also expected students to find the debrief productive in generating useful solutions to the bullwhip effect. Students appreciated that the game provided a low-stakes environment in which to experience the bullwhip effect, but none specified finding the discussions of solutions helpful—one even believed that part of the discussion was too shallow. However, students cited Belinay's explanations of how the bullwhip effect plays out using the game's graphs as being very useful.

With respect to **Success**, Belinay expected students to find the game easy to play—owing to her detailed rules explanation and examples—but hard to win due to the lack of complete individual control over the supply chain's success. She expected this lack of control to translate to an intended feeling of frustration among students. Similarly, students discussed that they knew how to win (theoretically) based on Belinay's briefing, but that actually doing well felt impossible once the supply chain started spiraling out of control.

For **Interest**, Belinay expected that most students were intrinsically interested in the material, as this course was an elective that students willingly volunteered to take, and would be interested to see that material applied in a game setting. She also expected students to appreciate a break from lecture. As Belinay expected, every student interviewee stated that the course and game were relevant to their professional and/or personal interests. Every student also stated finding the game enjoyable despite frustration and that they enjoyed the competitive elements of the game. Two students also appreciated Belinay's efforts to keep the game proceeding at a fast pace.

Caring was a MUSIC component about which neither Belinay nor her students had many comments. Belinay stated that her references to the game in future lessons would demonstrate that she cared that students found the game relevant. Belinay's students had no agreement regarding what teaching practices contributed to caring, but seemed to me to have a great deal of trust in Belinay to help them pull through the game's frustrations. One student responded that Belinay's empathy with students helped demonstrate caring during the game: "She kept laughing at us...like, 'Haha, see? This problem's actually difficult, so I'm kind of glad you're having fun.' ... She could absolutely understand the frustration that we were going through."

Victoria Case Summary

Case Characteristics

Month Collected	April 2018
Institution Type	Small, private, teaching-focused
Approx. Class Size	20 students
Academic Level	Juniors
Engineering Discipline	Chemical Engineering
Classroom Setting	Long classroom, flexible seating
Approx. Length of Class	50 minutes (game and debrief)
Approx. Length of Game	40 minutes (game), 15 minutes (debrief)
Help Available	N/A
Student Interviewees	4

Game Description

Victoria's game was a spreadsheet simulation game in which players attempted to optimize profit for a particular chemical reaction, where different reactor conditions and product purity yielded different costs and revenues. Victoria had been doing a similar spreadsheet simulation for eight years in her thermodynamics course, and decided to turn it into a competitive game four years ago. She conducted the activity as normal this year, but was uncertain how it would go, since her department had recently reorganized its curriculum and she was unsure what prior knowledge students were bringing from the new prerequisite courses.

Prior to the game, students independently prepared their own spreadsheets to automatically calculate the product of a specific chemical reaction (a water gas shift reaction) given the appropriate inputs (heat, pressure, moles of reactants, etc.) During the game, students were asked to modify these spreadsheets to incorporate the costs of different inputs and revenue from different product purities for the reaction, and use trial and error and optimize the reaction to maximize profit. Students were allowed to work alone or in self-selected groups. As students generated higher and higher profits, Victoria recorded the highest profits on a leaderboard projected at the front of the room. At the end of the game, the winner was awarded a plastic goblet with some chocolate in it. By using this game, Victoria hoped to introduce the idea that theoretically optimal conditions for a reaction often differ from optimal conditions to maximize profit in practice, which is an idea she expected students would explore in great depth during their senior design course the following year.

Observed Class Summary

The briefing and game took place in a single class period with all approximately 20 students. The debrief took place in two following lab sections of approximately 10 students each. I observed all of these class sessions.

Victoria began class by asking students to open their previously prepared spreadsheets and began her briefing process by framing the purpose of the game, stating that she wanted students to begin to consider chemical reactions as designers, rather than as students of chemistry. She stated the game's goal (to make a profit) and encouraged students to work in groups if they wanted, or work individually if they preferred. She introduced the incentive of the chocolate and explained the rules of the game, particularly by presenting the cost and revenue constraints that students would need to incorporate into their spreadsheets. She stated that this activity was a precedent for the kinds of design decisions they would need to make in senior design. She provided students with an initial time estimate of 30 minutes for the duration of the game, and then turned students loose to play.

As the game, began, Victoria walked around and began making idle chat with students (e.g., asking a student how a recent sports meet went.) Soon, questions began to pour in. From her post-interview, Victoria expected most student questions to be about how to update their spreadsheets for the new constraints she introduced, but the questions she got focused more on how to get the reactions to calculate correctly in their spreadsheets. She disclosed to me in the post-interview that she was expecting a greater level of student understanding of the reaction by this point, but the new prerequisites in her department's curriculum did not seem to prepare them as well as the old prerequisites had. In the time between questions, Victoria wandered around the room and checked on students to see how they were doing, occasionally asking to see their spreadsheets. About five minutes into the game, she announced that the first students to get positive profits should let her know so that she can update the leaderboard accordingly. About 25 minutes into the game, the first student announced a profit, and Victoria updated the leaderboard. Victoria let the game continue until the end of the class period, deciding to move the debrief to lab sections later in the week. She stated in the post-interview that many students were still unable to make a profit 30 minutes in, so she wanted to give them more time to try. She spent the remainder of the game answering student questions and updating the leaderboard as needed. At the end of the class period, she announced the winner and handed out the chocolate goblet.

Victoria began the debrief for the first lab section by asking students what did and did not work well for them during the game. As students responded, Victoria listed their responses on a whiteboard. When student responses did not touch on an idea she considered important, Victoria would ask a more question specific question to elicit a more specific response. After a few minutes of response, she asked what results students found surprising, and affirmed their responses. She then went point-by-point down the list she had made and related each point to how chemical reactors are designed in the real world. She concluded by reminding students that they would be doing similar work to the game in their senior design course.

The debrief for the second lab section was similarly structured, but students were less responsive, requiring Victoria to act more probing questions. Moreover, student responses steered more toward mathematical considerations, so Victoria used more mathematical demonstration in this section. Victoria ended this debrief more abruptly, and did not remind students that they would be doing similar work to the game in their senior design course.

MUSIC Summary

In general, Victoria's expectations for what motivated students were accurate in some instances and inaccurate in others. Victoria expected that students would feel successful by making progress through trial and error, but most student interviewees felt poorly equipped for **Success**. Victoria expected students to find the game's takeaways useful, and while students also appreciated the **Usefulness** of the game experience to their future coursework, those who struggled with Success cited few concrete takeaways. Victoria was correct in her expectation that students find **Interest** in the competitive elements of the game, though appreciation of the material prize varied.

Regarding **Empowerment**, Victoria expressed that students would find autonomy in their ability to work with whomever they want (or work alone), to design and manipulate spreadsheets as they wished. Students were also free to not participate if they so chose, though Victoria expected no one to take advantage of that freedom. Victoria's students echoed most of these points, but these sources of empowerment ended up damaging three students' perceptions of **Success** later in the game, as described below.

With respect to **Success**, Victoria expected that students would find the game easy to play but hard to successfully optimize, and that incremental successes in improving profit through trial and error would inspire students to want to continue playing with their spreadsheets throughout the game. Three of the four student interviewees, on the other hand, were not confident that the spreadsheets they created accurately modeled the chemical reaction, and thus they found the game difficult to play. All three of these students worked independently during the game, meaning they relied on time-constrained interactions with the instructor during the game to verify their spreadsheets. These students found it helpful that Victoria took the time to work with them when she could to troubleshoot their spreadsheets. The most common suggestion for improvement by students was a formal opportunity to verify their spreadsheets worked as intended prior to the game. The one student who did work in a team expressed no such reservations about her team's spreadsheet. None of the student interviewees expressed they believed they could win compared to their classmates, and two found it helpful that Victoria defined the milestone of making a positive profit as doing well, as they felt this goal was more achievable.

In terms of **Usefulness**, Victoria expected students would find the activity useful in that it was preparation for future coursework and an example of how chemical reaction design is implemented under real-world financial constraints. Students, despite feeling largely unsuccessful during the game, still found the activity relevant to their professional goals and believed it was good preparation for future coursework, as Victoria intended. However, **Success** had an important effect on Usefulness, as only the student who worked in a team and did reasonably well cited any relevant learning takeaways from the game. Moreover, Victoria's case was a rare instance in my study where students were ambivalent about the usefulness of the instructor's debrief: one believed it was critical in making the game feel useful, one believed it was too shallow to be useful, and the other two found it unremarkable.

For **Interest**, Victoria expected that students would find the game mildly interesting, and that perceptions of interest would be driven by the inclusion of competitive elements in the game, and in the desire to solve discrepancies between theoretically ideal reactions and practically ideal reactions. Students agreed that the game was mildly interesting (more interesting than lecture but not more interesting than other active learning activities done so far in the course), and that competition was important to their perceptions of interest. Students felt ambivalent about the material prize of chocolate for the winner; two liked it, and the other two found it completely extraneous. Most students also found the game relevant to their professional or personal interest, and two stated liking the game's level of challenge, even though they were not confident in the readiness of their spreadsheets to meet that challenge.

For **Caring**, Victoria expected she would demonstrate caring about student experience through the inclusion of a material prize and leaderboard, and by encouraging and helping students throughout the game. Most students agreed that Victoria's attention and help troubleshooting throughout the game demonstrated that she cared.

Miray Case Summary

Case Characteristics

Month Collected	November 2017
Institution Type	Small, private, teaching-focused
Approx. Class Size	10 students
Academic Level	Sophomores and Juniors
Engineering Discipline	General Engineering
Classroom Setting	Wide classroom, flexible seating
Approx. Length of Class	50 minutes
Approx. Length of Game	25 minutes
Help Available	N/A
Student Interviewees	4

Game Description

Miray's game was a cultural trading game meant to emulate the sensation of interacting with someone whose cultural norms are very different from one's own. It was an adaptation of the game *BaFa' BaFa'* created and marketed by the company Simulation Training Systems. Miray heard about the game from a colleague who asked her to help facilitate it in his class. She decided to use the game for the first time two years prior in her elective course on engineering communication, when she moved to her current university and observed it lack cultural diversity, with low international student representation. She has used it every year since, with this being her third implementation.

In the game, students were split evenly into two cultures and asked to play the roles of people in those cultures: (1) an alpha culture that was social, touchy, and proud, and (2) a beta culture that was reserved and desired personal space. The goal of the game was to conduct as many trades as possible with students in the other culture. Any classroom object or personal possession could be traded for a point, but only if the student interacted with the other culture in a way that the culture considered polite. The traded items were returned after the game. In the event of a successful trade, the student traded the object for a slip of paper that acted as currency to track scores. The catch was that what was considered polite in one culture was considered offense (and grounds for immediate trade rejection) for the other culture. Alphas only traded with students who touched their shoulder when presenting the trade, and betas loathed physical contact. Betas only traded with students who initiated a trade with the phrase "BaFa' BaFa'", which was an insult to one's family in the alpha culture. Each student had a worksheet describing their culture but knew nothing of the other culture. Therefore, students' goals were to figure out what to do to make a successful trade with the other culture. By using this game, Miray hopes to provide her students with an opportunity to reflect on the effort required to understand cultures very different from their own, and the mutual adaptation required for successful communication with that culture.

Observed Class Summary

Miray began class by having her 10 students organize into two groups of five that she determined semi-randomly prior to class. Some students seemed nervous about the seating change, and she tried to comfort the class. She then began a short briefing on the game. She explained the rules of the game, specifying that students would belong to different cultures with different norms. She explained how the game's trading and currency worked and stated that the objective of the game was to get the most currency as a culture by the end. She then handed out a sheet to each student describing their respective culture, and asked students to take 10 minutes to study their cultural norms and practice playing a role within their culture. She asked one group (the betas) to move into the lounge outside the classroom, so that each culture could practice in private.

Miray started facilitating the game in the classroom with the alpha culture. Students asked her many questions about their culture as they read, including rules clarifications and questions about strategy. Miray answered any clarification question but chose to withhold strategic advice. After a few minutes, Miray walked to the lounge to facilitate the betas. She noticed that the betas were all sitting down and not practicing their roles, so she encouraged them to stand up and interact. As they did, a few students asked Miray for feedback about their interactions, in response to which Miray gave some positive feedback and offered some tips for improvement. After a few minutes, Miray designated a student from each group as a "spy", who got to watch the other culture interact for one minute and then report back to their home culture. The alpha student who spied on the betas complained to Miray that the beta culture didn't actually interact much, and Miray encouraged her to give the best report she could, given what she saw. Groups then had approximately two minutes to prepare their trading strategies before the betas returned to the classroom and trading began.

During trading, Miray took a hands-off approach and observed. Neither culture completed a successful trade for the first five minutes. Some students seemed visibly frustrated, while others seemed to enjoy playing their roles. After five minutes, one of the alpha students called for her group to reconvene and re-strategize, and both groups discussed among themselves. In her post-interview, Miray revealed that this action was surprising to her but welcome. From student interviews, the alphas spent this time deciding that they should consider toning down their actions to accommodate the betas, and the betas spent this time deciding they should be more forgiving of the alphas for offensive actions. The groups reconvened for trading and some successful trades began to occur. One student from the alphas approached Miray lamenting that playing her cultural role was getting her nowhere, and Miray suggested that maybe she should try something new. As more trades were successful, Miray called time and began the debriefing process.

She gave each student a worksheet with reflection questions and asked the betas to return to the lounge outside the classroom. The questions were as follows:

- How did you feel when you were preparing to take on the role of a new culture?
- How did the other culture appear to you from your cultural perspective? Describe them with adjectives.
- Explain the rules of the other culture.
- How did it feel to interact with the other culture?
- What strategies did you use to adapt to their culture?
- Did the other culture react the way you expected them to? Why or why not?

She then told each group that they should frame their reflection by considering the group's cultural norms in relation to their own. She encouraged students to discuss among their groupmates as they reflected, but students continued to work individually regardless. After about five minutes, Miray invited the betas back into the classroom and began the debriefing discussion in earnest. She asked students how much currency they ended up with, but she did not dwell on that outcome or announce a winner. Instead, she jumped straight into each reflection question one-by-one, and asked students to share their responses with the class. She affirmed their responses and recorded them on a whiteboard. After getting through all the questions, she offered her perspective on how the game connected to real-world engineering and helped students connect the outcomes of this activity to those of previous activities students had done in the course. Finally, she gave students an opportunity to share their own takeaways from the activity before announced her intended takeaways.

MUSIC Summary

In general, Miray and her students agreed that the **Usefulness** of the activity was a critical aspect of student motivation, with student **Interest** discussions also revolving around aspects of the activity that made it useful. Miray's case was also one of few cases where **Caring** appeared to play a major role in the instructor-student relationship, and where issues of authority affected student motivation, particularly as they related to **Empowerment**.

Regarding **Empowerment**, Miray expected that would feel empowered to act freely within the game's rules due to the openness of the game's ruleset, and expected students would particularly exercise this freedom with respect to the extent they adapted to the other culture. Most student interviewees agreed that they have plenty of freedom within the game, but an equal number of students expressed that it was unclear how far from their cultural rules they were allowed to deviate—no one wanted to break the rules. Two students also appreciated having some control over the direction of the debrief discussion.

In terms of **Usefulness**, Miray believed that the game itself was a useful experiential learning activity, but expected that this usefulness would be most apparent to students during the game's debrief. Student interviewee responses proved her expectations correct, as students had little agreement regarding what about the game itself was useful, but all of them appreciated the debrief. Students particularly appreciated hearing Miray's perspective on why the game was useful to real-world engineering.

With respect to **Success**, Miray expected that students would find the game hard to win, as they had to adapt from their cultural norms to accommodate the other culture, and had limited time to deduce what kinds of adaptations were appropriate. She expected that the opportunity to spy on the other group would help them identify appropriate adaptations. In line with Miray's expectations, all student interviewees expressed that unsuccessful trades near the beginning of the game made them question their ability to succeed, but adapting to the other culture yielded some successes that helped boost morale. Students disagreed with Miray on the usefulness of spy time; some interviewees felt that their group gained no useful information from spying, and others stated that learning the other group's norms were the opposite of theirs made them question whether success was even achievable.

For **Interest**, Miray expected that she does enough active learning activities that they trust her to eventually explain the relevance of the activity to their personal and professional interests. Based on feedback from previous years, she also expected students to find the game fun, and that they would consider the game's competitive elements to be a big part of that. Miray was correct that students found the game relevant to their personal and/or professional interests, and that they found it fun. Students also appreciated Miray's enthusiasm about the game and the fact that they didn't have to sit through a lecture, but there was little convergence in student responses beyond that. Miray's case was one of the few in which students did not specify competition as a major contributor to Interest.

For **Caring**, Miray believed that she built a sense of caring with students over time, as she meets with them regularly for one-on-one feedback and always tried to connect activities to how they would help students be successful as professionals. Students echoed both of these sentiments, and especially appreciated that she always focused on the practical/professional takeaways from activities.

Appendix E: Comparing student responses between research & teaching universities

The table below presents the difference between the number of students at teaching universities and the number of students at research universities who cites a given OPAL category as affecting student motivation via a given MUSIC component. There were 11 student participants at each type of university, so the data was not normalized. For example, 8 students at research universities cited Task Structure of the Game as affecting Usefulness, while only 3 students at teaching universities did. Therefore, that OPAL-MUSIC pairing is listed at -5 (3 – 8) in the table, indicated that it was cited by 5 more students at research universities than students at teaching universities. If the number were positive, it would indicate that more students at teaching universities cited that pairing.

– | +

Students at research uni. emphasized more | Equal Emphasis | Students at teaching uni. emphasized more

	MUSIC Component				
OPAL Category	**M**	**U**	**S**	**I**	**C**
Task Structure (During Game)	-1	-5		-1	+1
Task Structure (Before/After Game)		+2	+5	+2	+1
Authority	+2		+3		
Autonomy	-1		+1		
Recognition and Feedback			-2	-2	+1
Grouping & Roles	-2	-4	-1	-2	
Evaluation and Assessment	-2	-3		+1	-2
Use of Time		-2	-2	-2	-1
Social Interactions		-1	-4	+1	+4
Help-Seeking Strategies and Responses			+2		+1