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A Case Study Of A Flipped Curriculum Using Collaborative And Active Learning With An Adaptive Learning System

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A CASE STUDY OF A FLIPPED CURRICULUM USING COLLABORATIVE AND ACTIVE LEARNING WITH AN ADAPTIVE LEARNING SYSTEM

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ABSTRACT

This case study examined a graduate medical program in the Western United States that was redesigned to use adaptive learning with active and collaborative classroom learning in a flipped environment. Findings suggested student comprehension of material was as good or better than prior to the redesign, and students were able to complete coursework more efficiently, getting into the clinical environment sooner. Students' improved abilities to apply knowledge was due in part to the capabilities of the adaptive system, the collaborative and active learning environment in the classroom, and the rapport and relationships built with the faculty. The multifaceted design of this curriculum stood to serve a wide variety of student needs in this complex system. Two overarching conclusions can be drawn from this study. First, the redesign of the curriculum, through unbundling and rebundling of content and integrating it across all aspects of dentistry, made for a much more effective curriculum. The redesigned curriculum was centered on patient care and scaffolded to meet the needs of the learner. This redesign filled gaps and eliminated redundancies in the content. The restructured content gave students a more meaningful introduction to the material and quicker access to hands-on dentistry work in the clinical experience, which helped affirm students' aspirations to become dentists. Second, the combination of adaptive learning and active and collaborative learning delivered in a flipped model was an optimal learning environment for this program. Students benefitted by interacting and collaborating with other students in the classroom and receiving feedback from peer and faculty reviews of their work. Students found it motivating and supportive to discuss

coursework and cases with other students and benefitted from the coaching given by the faculty members circulating among students in the classroom. The adaptive platform increased the efficiency of learning. Students learned in a shorter amount of time. The adaptive learning system provided the ability to deliver well-designed content effectively outside of class with efficient and personalized learning paths, frequent assessments, and analytics on student activity and achievement. Additional research on the outcomes of other programs that use adaptive learning and active, collaborative learning in a flipped environment are needed to understand the generalizeability of this educational model.

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CHAPTER 1

INTRODUCTION

Surviving and thriving in a knowledge society requires broad and deep understanding of many facets of a complex world. Information is produced at an increasingly rapid pace, leading more people around the globe to pursue a college degree as a way to try to keep pace with the unceasing creation of new information (Altbach, 2016; Kegan, 1994). Higher education has long been seen as a means to advance understanding of humanity and the world and to improve career opportunities (Arum & Roska, 2011; Bastedo, 2016; Newman, 2003). However, colleges and universities have recently received heavy scrutiny as editorials from authors such as Zemsky and Massy (1990), research reports like that from the Center for College Affordability and Productivity (2010), and government-sponsored reports (Harvey, Williams, Kirshstein, O'Malley, & Wellman, 1998; Secretary of Education's Commission on the Future of Higher Education, 2006) questioned the cost and value of a college education (Bastedo, Altbach, & Gumport, 2016; Middaugh, 2010). In 2008, the Higher Education Opportunity Act called for institutions of higher education to demonstrate greater student outcomes (Dickeson, 2010; Martin & Samels, 2009; Middaugh, 2010). In 2011, Arum and Roska published a highly critical view of higher education in the widely-publicized book, *Academically Adrift,* which received news coverage in higher education trade publications as well as National Public Radio. As a result of external pressures to demonstrate positive student outcomes, college and university

administrators have increased efforts to improve retention, graduation rates, grades, and other student learning outcomes (Middaugh, 2010). The need for increased learning outcomes has required the development of new solutions to enhance learning.

Our understanding of how people learn continues to grow. Researchers have studied how people process and retain information and have suggested methods for increasing human understanding and application of new knowledge (Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000). People learn better through recalling prior knowledge, processing new information, and connecting new knowledge to something they already know (Bransford et al., 2000; Medina, 2014). Social interaction with peers and active learning practices can aid the learning process. When designed appropriately, social engagement can enhance what students are able to understand and apply through their dialogue and interactions with others around a specific challenge or task (Bandura, 1977; Bandura, 1986; Vygotsky, 1935/1978). Vygotsky observed that children were able to perform new tasks in social settings with the help of others earlier in their cognitive development than they were able to perform the tasks individually (Noddings, 2016). Active learning can lead to better student learning, application, and attitudes (Bonwell & Eison, 1991; Hall & Saunders, 1997). Physical classroom spaces can also impact student learning. Active learning classrooms combine pedagogies of active learning strategies with physical classroom design, such as seating students in small groups at round tables to encourage student-student collaboration as new ways to have students engage with and apply what they are learning (Baepler, Walker, Brooks, Saichaie, & Petersen, 2016; Beichner, 2014).

Educating students does present challenges. Researchers in the Association of Public and Land-Grant Universities, Personalized Learning Consortium (n.d.) stated, “The great challenge confronting university educators, especially faculty teaching large 100- and 200-level general

education courses, lies in understanding what individual students already know and what they need to know" (para. 1). Students do not have the same background experiences, skills, or prior knowledge when they enter a class, and they do not learn in the same manner or at the same pace (McKeachie & Svinicki, 2006).

Technological tools may be able to help address the personal learning needs of each student and enhance learning gains. Adaptive learning systems use artificial intelligence and analytics to aid the teaching and learning processes and adapt to the needs of students. Adaptive learning systems measure student prior knowledge, convey desired outcomes to students, establish optimal learning paths, gather metrics and evaluate a student's state of understanding, and remediate to fill knowledge gaps and reassess students (Dziuban, Moskal, & Hartman, 2016; Pugliese, 2016). Lovett, Meyer, and Thille (2008) indicated that students required half as much time to learn course content when adaptive learning was implemented. Retention and grades can also be enhanced through the use of adaptive learning. Some studies have shown that the use of adaptive learning in gateway courses can increase retention and scores (Bowen, Lack, Chingos, & Nygren, 2012; Dziuban, Moskal, & Hartman, 2016). Another study showed adaptive learning systems could enhance critical thinking skills when applied in a flipped class environment (Y. Yang, Gamble, Hung, & Lin, 2014). Results like these could help address the problem of keeping up with the rapid growth of knowledge production and help address critics' concerns that higher education is not doing enough to educate students.

Statement of the Problem

While the application of adaptive learning in college courses has been shown to enhance knowledge acquisition in some cases, it has not always led to significant, positive results. In one study, Yarnall, Means, and Wetzel (2016) found little-to-no improvement in retention, and

students were generally dissatisfied with the adaptive learning system. Two studies showed no significant improvement in grades (Coffin Murray & Pérez, 2015; Griff & Matter, 2013). When comparing the different elements of the studies, the authors said the variables appeared related to issues of implementation, such as course design, choice of adaptive system, or student and faculty preparation for using the system (Coffin Murray & Pérez, 2015; Griff & Matter, 2013; Yarnall et al., 2016).

Technology alone cannot lead to effective learning (Dick & Carey, 1996). Optimal learning requires careful curriculum design, effective pedagogical strategies, purposeful interactions and engagement, aligned assessments, intentional application of technology, adequate faculty and student preparation, and student motivation, among other things (Dick & Carey, 1996; Fink, 2013; Gagne, Briggs, & Wager, 1992; Wiggins & McTighe, 2005). Adaptive learning systems deliver personalized content and assess student understanding, but they do not incorporate pedagogical practices that address other cognitive, collaborative, and active learning needs of students.

Implementations of active learning, class discussion, faculty coaching, experiential learning, social interaction, and other methods have been shown also to enhance student learning (Bandura, 1986; Burbules & Bruce, 2001; Chickering & Gamson, 1987; Hake, 1998; Kolb, 2015; McKeachie & Svinicki, 2006; Vygotsky, 1935/1978). Yet, these non-technological methods do not offer the power of immediately assessing student knowledge deficiencies and adapting teaching and assessment to the individualized needs of every student among a class of many students. Further, non-technological methods cannot collect analytical data on each student's engagement and performance to the degree an adaptive system can. Being able to combine adaptive learning with effective classroom teaching would appear to offer the

advantages available through active and collaborative classroom learning and technology-based adaptive learning. This research study will explore one case which has implemented adaptive learning in conjunction with an active and collaborative learning classroom environment with positive results.

Purpose of the Study

The purpose of this qualitative case study was to explore curriculum design and faculty and student experiences in a graduate program using a flipped course design model that incorporates an adaptive learning system coupled with active and collaborative classroom learning. A case study site was selected that has increased standardized test scores and retention rates following a redesign that implemented a flipped classroom model that combined the technology of adaptive learning courseware with active learning in an active and collaborative classroom environment. This study examined the design, the experiences and perceptions of students and faculty members, and the outcomes of this program.

Significance of the Study

Bowen et al. (2012) and Lovett et al. (2008) found that traditional learning time was cut by one-quarter to one-half with the use of adaptive learning, suggesting that the learning processes may be greatly expedited through the efficacious application of adaptive learning technologies. However, not all implementations of adaptive learning systems have demonstrated effectiveness (Coffin Murray & Pérez, 2015; Griff & Matter, 2013). Adaptive learning systems are fairly recent technological developments, and not many studies exist that focus on the effectiveness of the implementation of the adaptive system in a learning environment (Dziuban, Moskal, Cassisi, & Fawcett, 2016). Much of the research in adaptive learning is technical in nature. This study sought to understand the implementation exhibited in this case and its

application of adaptive learning in a flipped model using active and collaborative classroom learning.

Research Questions

Through the lenses of instructional design and social development theory, this research answered to the following research questions:

1. Why and how was the design of the curriculum of a graduate medical program in the Western United States changed?
2. Have, and, if so, how have student outcomes in the graduate medical program in the Western United States changed following the curriculum redesign?
3. How do students and teachers describe their perceptions of and experiences with adaptive learning in the graduate medical program in the Western United States?
4. How do students and teachers describe their perceptions of and experiences with active learning and collaborative learning in the graduate medical program in the Western United States?

Research Design

Creswell (2013) said that a case study approach is appropriate when the researcher has identified a bounded system and seeks to provide an in-depth understanding of the case. This qualitative case study will examine an institution of higher education in the Western United States that has redesigned the curriculum to incorporate active and collaborative learning in the classroom and adaptive learning outside of the classroom using a flipped model.

The program director and designers of the graduate medical program in the Western United States were interviewed in order to understand what elements were included in the curricular redesign and why. Face-to-face, semi-structured interviews were conducted with

faculty members teaching in the program and with first- and second-year students who were in the two-year pre-clinical program. A sampling of graduates of the program were sought for interviewing; however, none responded. Observations of classroom activity and general hallway and campus surroundings were conducted. Artifacts and documents related to program design, faculty and student experiences, and outcomes of the program were collected and analyzed. All data were analyzed to uncover themes, and the findings and case are described in detail in this document. Themes may offer lessons for curriculum designers, faculty members, instructional technology leaders, and academic program leaders interested in implementing technology designed to increase the capacity of human learning.

Limitations

Creswell (2013) indicated that researchers approach their research with certain inherent philosophical perspectives which shape how they collect, analyze, and interpret data. These perspectives were proactively addressed in the design of the research (Ary, Jacobs, & Sorenson, 2010). In this study, researcher bias was controlled through methods of bracketing personal experiences and prior assumptions, searching for and explaining contradictory data, collecting data from multiple sources, spending prolonged observation time at the site, checking with participants to confirm understanding and interpretations, and utilizing peer review (Ary et al., 2010; Creswell, 2013).

A second limitation was that the individuals who participated in this study have their own unique backgrounds, motivations, and world views. They have unique perspectives that they shared in interviews that may be limited or biased. The program director helped identify faculty to interview, and those faculty members may have a biased view of the curriculum design. Due to limitations of time and resources to remain on site, only two students were interviewed,

although all students in the pre-clinical program were observed. The limited number of student voices may present a narrower view of student experiences and perceptions than had more students been interviewed. Interviewing techniques were used to control for reliable information, including observing for discrepancies of verbal and non-verbal cues, using probes and pauses, and asking for concrete details (Ary et al., 2010).

Another limitation of this study may include an inability of participating students to pinpoint exactly what elements of the program design impacted their academic performance and experiences. In order to control for this limitation, interview questions were used to help students recall their experiences and explore their learning. Faculty interviews and site observations assisted the researcher in increasing understanding of what design elements contributed to student learning and experiences and were used to triangulate and report findings.

Delimitations

This study was conducted with current staff, faculty members, students, and a retired leader of a program at a selective medical school. With these parameters, the results may not apply to undergraduate programs, K-12 programs, or other disciplines.

Findings from this study cannot be generalized to all programs in higher education. Knowledge gleaned may be useful for leaders of other programs, but results cannot be guaranteed. Generalization was not the goal of this study, but themes may provide strategies other institutional leaders may consider implementing within their programs.

Definition of Terms

Definitions of terms used throughout the study include the following:

Active learning is defined as an instructional method that engages students in the learning process and requires them to do some meaningful learning activity in which they think about what they are doing (Prince, 2004).

Adaptive learning is defined as technology that adjusts content delivery and assessments to meet the learning needs of each student (Pugliese, 2016).

Course delivery consists of all the activities and interactions that the instructor does in order to help students learn once the course begins (Quality Matters, 2015).

Curriculum refers to "the means and materials with which students will interact for the purpose of achieving identified educational outcomes" (Ebert, Ebert, & Bentley, 2013, para. 1). It can also mean anything from learning objectives, to educational materials, to assessments ("Curriculum," 2015).

Curriculum design refers to the design and integration of teaching strategies, content, learning activities and experiences, and assessments (Fink, 2003).

Flipped classroom, for the purposes of this study, refers to a course design that places lecture content acquisition outside of class time and application, problem solving, and group work in the classroom (Bergmann & Sams, 2012).

Self-efficacy is defined as one's belief that one can do the task (Alt, 2015).

Summary

The goal of this study was to examine a case in which technology-based adaptive learning courseware is paired with active and collaborative classroom learning in a flipped model to learn about faculty and student experiences, perceptions, and outcomes of this program design model and strategies. With the increasing pressures on colleges and universities to decrease

time-to-degree and increase student learning outcomes, it is necessary to enhance student learning.

Active and collaborative learning has been shown to increase understanding (Bandura, 1986; Hake, 1998; Vygotsky, 1935/1978), and blended and flipped learning has been shown to increase learning outcomes over either fully online or face-to-face modalities (Means, Toyama, Murphy, Bakia, & Jones, 2010). Adaptive learning systems provide ways to increase the efficiency of student learning by measuring gaps in understanding and presenting content intended to fill the gaps (Brown, 2015). Additionally, these systems have detailed analytics that give faculty members precise information regarding what, when, and how long students are studying and how they are performing on assessments so that faculty members can provide appropriate guidance to students (Pugliese, 2016). Studying how all three of these elements—adaptive, active, and collaborative learning—have been incorporated into a curriculum design and exploring faculty and student perceptions, experiences, and outcomes could provide valuable insights for leaders of other programs.

The dissertation is divided into five chapters. Chapter 1 has included an introduction, statement of the problem, purpose statement, research questions, significance of the study, research methods, limitations, delimitations, definition of terms, and summary. Chapter 2 includes a review of the literature related to this study. Chapter 3 provides the methodology, method of inquiry, research questions, selection process and participants, data collection, data analysis, and validity and reliability. Chapter 4 contains a detailed description of the case study program and findings of the the study. Finally, Chapter 5 consists of a summary of the findings, discussion of the findings, conclusions, implications, and suggestions for further research.

CHAPTER 2

REVIEW OF LITERATURE

Learning is a complicated process which occurs hidden inside the brain (Bransford et al., 2000). Parents have experienced the wondrous joys of watching their children begin to learn new things. They have watched and heard their children learn to speak and understand the meaning of words as parent and the baby "read" a picture book together. They have watched their babies experiment and struggle until they learned to roll over for the first time or take their first steps. While parents can see their child's outward behavior develop and advance in skill and proficiency, parents do not see what is happening inside the child's brain to know what has caused the learning to take place. Parents who have more than one child have seen how no two children learn in exactly the same way. One child may learn to speak sooner, one may crawl before she walks, and one may skip crawling and go directly to walking.

Similarly, in schools, teachers see students' performance on tests and hear and see their responses in classroom discussions to gain a sense of what their students know, but teachers, like parents, cannot see inside the mind of each child to know exactly what causes learning to occur (Sawyer, 2014). Something that stimulates one student to learn may be misunderstood by another student because the two students have differing prior knowledge and experiences to which to associate the new content they have encountered (Bransford et al., 2000). Students enter classrooms with different backgrounds and experiences, different levels of academic

preparation, and different ways of learning (McKeachie & Svinicki, 2006). Teachers are challenged to help all their students reach a level of subject-matter knowledge attainment so that the students may advance to the next set of courses in their program and ultimately matriculate with a degree (Bransford et al., 2000).

Advances in technology are attempting to address the challenges of students' different learning needs (Brown, 2015). One technology is adaptive learning systems. Developers of adaptive learning have built upon the early capabilities of programmed instruction to design systems that dynamically identify individual student's learning gaps using artificial intelligence and item-response theory to assess prior knowledge and re-assess for knowledge gained (Pugliese, 2016). These systems are intended efficiently to help students learn new content by feeding them material that will help them learn what they do not already know and are based on current understanding of how people learn and what methods best help them learn (Brown, 2015).

This literature review will examine the advances in cognitive science to what we now understand as the learning process. It will also explore related learning theories and aspects of student development theory. This chapter will also review course design theories and delivery strategies to examine effective practices of designing and delivering education. Finally, this section will examine adaptive learning and the application of adaptive systems in various teaching environments to convey the current state of adaptive learning and the findings of empirical studies.

Tracing the Roots of College Student Cognitive Development

Our first records of the study of the nature of education and the process of educating, or educational philosophy, date back over 2,000 years to Plato and Aristotle (Noddings, 2016). In

reviewing different educational philosophies, we find that many and varied views exist on the purpose of education and the process of educating. Plato believed education was to prepare people for needed roles in society, whereas Aristotle stressed reason and moral education (Noddings, 2016). Locke viewed the child's mind as a blank slate and that people are products of their education, and Rousseau sought to isolate children from the corruption of society and educate children based on their innate curiosity and interests (Noddings, 2016). Dewey (1938) believed education should be tied to experience and students should learn by doing. Steiner believed in educating the head, the heart, and the hand—thereby developing the student's intellect, feelings, and practical skills (Noddings, 2016). While these are just a few of the philosophers and their views of education, it is clear that they differ on the purpose of education and the best ways to approach educating students.

Early colleges in the United States were modeled after the British system of higher education which used lectures, recitations, and public disputations as the primary mode of instruction (Bastedo, 2016; Thelin, 2011). This tradition continued over the centuries. In the late 1800s and early 1900s, educators like Dewey, Maria Montessori, and others argued for more hands-on learning (Dewey, 1938; Noddings, 2016). Yet, active and engaged, hands-on learning did not become the primary pedagogical practice (Bransford et al., 2000). Thelin (2011) said that historical records of teaching practices in the 1930s spoke of professors reading from aging lecture notes as the primary method of teaching. Following World War II, a large growth in college enrollment meant teaching methods had to accommodate more students. Lecture-based teaching styles continued as a primary teaching method, as they could more easily accommodate large numbers of students than active and hands-on learning that Dewey encouraged (Thelin, 2011).

Public education in the United States was formed on the basis that knowledge was a "collection of facts about the world and procedures for how to solve problems" (Sawyer, 2014, p. 1). Because of that view, the role of public education in society has often been to transmit knowledge from one who knows—the teacher—to one who does not know—the student (Sawyer, 2014). This is known as teacher-centered learning (O'Neill & McMahon, 2005). Carroll (1963) developed a theory that introduced the concept that different students require different amounts of time to learn. He determined that the degree of learning is based on a function of the amount of time a student spends learning, divided by the amount of time a student needs to spend learning. A few years later, a new science of learning began with a goal of understanding the complex process of how people learn (Bransford et al., 2000). This area of research has emphasized a different focal point and has led to a paradigm shift, moving the focus from what is taught to what is being learned (Barr & Tagg, 1995).

Cognitive scientists reached agreement on several basic tenants of learning following two decades of studying the learning process. The seminal work *How People Learn* shared what was then understood about the science of learning and integrated that understanding with application to the practice of teaching (Bransford et al., 2000). Much of the findings were reaffirmed and built upon in later works, such as the *Cambridge Handbook of Learning Sciences* (Sawyer, 2014). In the time since those publications, researchers have continued to refine several broad concepts to guide current understanding of how people learn.

Before discussing specific ways in which people learn, we must first differentiate between types of knowledge. L. Anderson and Krathwohl (2001) described knowledge, or cognition, as being either factual (declarative), procedural, conceptual, or metacognitive. Factual or declarative knowledge exists in discreet pieces of information and is considered objective.

Procedural knowledge consists of steps to be performed; conceptual knowledge is represented by interrelated complex schemas, and metacognitive knowledge consists of being aware of one's own knowledge and that of others (L. Anderson & Krathwohl, 2001). These distinctions between different classifications of knowledge are needed when considering how people learn.

Learning scientists have identified several core elements of learning. First, people need deep conceptual knowledge such that they learn objective facts but also broader concepts surrounding the facts (Bransford et al., 2000; Sawyer, 2014). The researchers recommended that teachers give deep coverage on fewer topics while providing numerous examples to aid students' conceptual understanding and their ability to apply the concepts to new situations (Bransford et al., 2000).

Researchers also found that learning was most effective when teachers engaged students' pre-existing knowledge:

> Humans are viewed as goal-directed agents who actively seek information. They come to formal education with a range of prior knowledge, skills, beliefs, and concepts that significantly influence what they notice about the environment and how they organize and interpret it. This, in turn, affects their abilities to remember, reason, solve problems, and acquire new knowledge. (Bransford et al., 2000, p. 10)

This finding suggests that teachers should seek to understand what their students already know, and at the same time assess accuracy and correct any fallacies in students' pre-existing knowledge. Further, initiating student recall of prior knowledge, relative to the content being studied, in advance of learning new things helps students assimilate new information with existing (Bransford et al., 2000). The researchers found that having students reflect on their learning was a key element in helping the students gain metacognitive skills (Sawyer, 2014) and

learn to "take control of their own learning by defining learning goals and monitoring their progress in achieving them" (Bransford et al., 2000, p. 18). Taking control of their own learning can help students develop good practices for continued learning outside of formal education (Chickering & Gamson, 1987; Sawyer, 2014). Understanding human learning allows teachers to design instruction to align better with the way people learn in order to enhance knowledge attainment and understanding (Bransford et al., 2000).

Educators need to focus on not only what was being taught but on what students were actually learning (Bransford et al., 2000; Sawyer, 2014). Bransford et al. (2000) said that, for most of the 20th century, educators were not focused on student learning but rather on what the teachers were teaching. A shift to focusing on what students were actually learning started in the 1960s with Carroll's model and continued to grow through the end of the century. This focus on student learning has come to be known as student-centered learning (Lea, Stephenson, & Troy, 2003).

Adaptive learning systems have been designed to focus on what individual students are learning. The concept of the adaptive learning system is built upon a foundation of learning science and has infused several teaching strategies previously mentioned (Brown, 2015). Adaptive systems use pre-tests to assess student prior knowledge and stimulate recall of existing understanding (Pugliese, 2016). An adaptive system focuses on what students are learning by measuring what each student knows then develops a model of each student. The system compares each student model to a model of what the student should know by the end of the course and measures each student's gaps in understanding. The system then develops a personalized learning path of content based on what each student does not already know. The design of adaptive systems takes into consideration that the time needed to learn varies by

student, addressing Carroll's (1963) model. Some adaptive systems allow students to choose to follow the system-prescribed learning path or to follow their own learning path, as a way to give students control of their learning (Pugliese, 2016).

Adaptive systems are particularly adept at delivering and assessing declarative and procedural knowledge; however, conceptual and metacognitive knowledge is more challenging to accomplish (Dziuban, Moskal, Cassisi, et al., 2016). The key challenge for adaptive systems is assessing conceptual and metacognitive knowledge, but some faculty members and course designers have had success in assessing conceptual knowledge attainment through the use of case studies (Dziuban, Moskal, & Hartman, 2016). Other faculty members or course designers have paired adaptive learning with classroom learning that addresses application of conceptual and metacognitive understanding (Y. Yang et al., 2014).

Student Development

Student learning is impacted by many factors. Students' unique characteristics, learning needs, backgrounds, and preparation impact their learning success (Carroll, 1963; Kauffman, 2015; Kerr, Rynearson, & Kerr, 2006). Motivation, self-direction and regulation, self-esteem, and self-efficacy are developmental characteristics related to learning (Pintrich & De Groot, 1990; Torenbeek, Jansen, & Suhre, 2013). Student development theorist Nevitt Sanford proposed that student academic success requires readiness, challenge, and support. To Sanford, readiness results from a combination of internal processes associated with students' maturity or external factors that students find to be beneficial to them (as cited in Patton, Renn, Guido, & Quaye, 2016).

Other researchers have focused specifically on achievement motivation of students. According to the expectancy-value theory developed by Atkinson and expanded upon by

Wigfield and Eccles (2000), students' motivation to achieve can be described as the result of students' expectations of how well they will do and how much they value the activity. Wentzel and Wigfield (2007) said that when students value achievement in different educational tasks or activities, the value may stem from internal reasons or external incentives for engaging. Students may be interested in the activity itself or its importance or usefulness to the them (Wentzel & Wigfield, 2007). McKeachie and Svinicki (2006) indicated that motivation consists of five components: autonomy and choice; intrinsic and extrinsic motivation; goals and whether they are for mastering a subject or obtaining a certain level of performance or grade; students' attribution of their success or failure, whether it is stable and in their locus of control and responsibility; and social goals and social motivation, or the need for belonging and support from or to others. The level and source of achievement motivation may have a significant impact on student readiness and likelihood of success (Wentzel & Wigfield, 2007; Wigfield & Eccles, 2000). Course designers, faculty members, and adaptive systems designers must consider student motivation in the design of systems and instruction (McKeachie & Svinicki, 2006; Vandewaetere, Vandercruysse, & Clarebout, 2012). Building in support mechanisms, opportunities for making choices in the learning path, and abilities to monitor performance are all ways course and system designers have sought to motivate students (Magnisalis, Demetriadis, & Karakostas, 2011).

Cognitive Development

Bransford et al. (2000) advocated for student-centered course design. ADDIE is a common model of instructional design, and it starts the design process with an analysis of the students, then proceeds to designing instruction, developing instruction, implementing, and then evaluating and revising instruction (Gagne et al., 1992). An examination of students and their development is the starting point for considering student learning, satisfaction, and self-efficacy

(Patton et al., 2016).

The cognitive development of the students can vary. Students enter college in one of several stages of development, including cognitive development (Patton et al., 2016). Cognitive development is defined as "the process of acquiring intelligence and increasingly advanced thought and problem-solving ability from infancy to adulthood" ("Cognitive Development," n.d.). Piaget asserted that neurological development precedes learning, meaning that children's brains must develop before they are to be ready to process new information at the next level (Patton et al., 2016). Piaget conceived of four levels of intellectual development, progressing from concrete to abstract and consisting of four stages of maturation (Sawyer, 2014). Logical and abstract thinking, which are expected in college, begin in the last two stages (Patton et al., 2016). The third stage, concrete operational, begins in middle childhood and is the point at which students begin to think logically but with limited abstraction abilities (Loughran, 2010). In this stage, students may be tempted to memorize answers to questions they believe will be on tests rather than seek to understand the underlying concepts (Patton et al., 2016). Although Piaget determined this was a cognitive level occurring in middle school, many a college professor has been apt to say their students are only interested in memorizing answers to score well on tests and they have no interest in developing further depth of understanding. Following this stage, Piaget called the final stage of intellectual development formal operational (Patton et al., 2016). It represents a cognitive level at which students can apply new concepts across multiple settings, think critically, use deductive and hypothetical reasoning, think in abstract terms, make rational judgments, and solve problems (Loughran, 2010). Student cognitive development impacts the level at which students are prepared to learn (Patton et al., 2016). It also touches on what may drive or motivate students to learn and engage in content (Loughran,

2010).

While Piaget studied children, William Perry in the 1950s and 1960s studied college students and how they made meaning out of the teaching and learning process (Patton et al., 2016). To Perry, college students' cognitive abilities start from what he called a dualistic position, in which students view things as either right or wrong. Their abilities then develop into a relativistic position, in which they acknowledge the possibility of varying right answers depending on the perspective taken. Finally, their abilities develop into the commitment-level, in which students are able to weigh differing opinions and perspectives then committ to what they believe to be the best answer (Patton et al., 2016). Unlike Piaget who believed students advance through stages of cognitive development in a predictable sequence, Perry believed that at any single point in time, a student could be functioning at different cognitive levels depending on the subject area (David, 2014; Patton et al., 2016).

Using Perry's positions as a lens into the cognitive development of students, teachers can use techniques to expand their students' current levels of thinking by introducing them to other viewpoints and challenging them with examples and case studies to stimulate debate (Loughran, 2010); however, Perry found that students can digress from a trajectory of cognitive growth if they are challenged too much without adequate support. Students may temporize, escape, or retreat to a lower cognitive level if they face too much challenge and not enough support and sense of progress (Patton et al., 2016). Support can come from the teacher and other students or be built into adaptive courseware or other course materials (Gagne et al., 1992). One other applicable finding of Perry's research was that students who think at the dualistic level are more apt to expect teacher-centered methods, whereas students who have moved to relativistic thinking are more likely to be comfortable with student-centered methods (Lea et al., 2003;

Perry, 1970; Stevenson & Sander, 2002).

Active Learning

Harden and Crosby (2000) described teacher-centered learning as focusing on the teacher transmitting knowledge, whereas student-centered learning focuses on what students are learning and "what students do to achieve this, rather than what the teacher does" (Harden & Crosby, 2000, p. 335). This view of education emphasized the concept of the student "doing," or being actively involved in learning. Active learning requires students to "do meaningful learning activities and think about what they are doing" (Prince, 2004, p. 223). Active learning can increase student learning (Hake, 1998; Hall & Saunders, 1997; Redish, Saul, & Steinberg, 1997). Hake (1998) found that the test scores of 6,000 physics students increased by 50% when the teaching methods were changed from traditional lecture to student interaction and engagement with the content and each other.

In addition to having students be actively involved in their learning, researchers found that having a learning environment that allowed real-life application of new knowledge had a significant impact on learning (Bransford et al., 2000; Sawyer, 2014). While these findings are not new—educational philosophers like John Dewey drew this same conclusion a century ago (Dewey, 1938; Noddings, 2016)—they do re-introduce the value of active learning. Scholars have again highlighted the benefits of hands-on learning.

Social Learning and Social Development

Student development psychologists like Sanford indicated that students need support and challenge (Patton et al., 2016). Vygotsky (1935/1978) saw social interaction as an effective method of supporting student learning. In his social development theory, Vygotsky claimed that learning is easier when new concepts are within students' zone of proximal development and

when they engage in social interactions with more knowledgeable others (Loughran, 2010; Noddings, 2016; Vygotsky, 1935/1978). Vygotsky's zone of proximal development is a concept describing the difference between what students can learn on their own and what they can learn with knowledgeable adults or students (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010; Vygotsky, 1935/1978). Optimal learning takes place when students are challenged at a level that is slightly higher than their current understanding (Vygotsky, 1935/1978). In order to challenge students at a slightly higher level, teachers must know the student's present level of understanding (Bransford et al., 2000). Adaptive systems are designed to support students through directing them to content within their zone of proximal development in order to fill gaps in understanding. However, adaptive systems use technology to support students rather than other students in a social context (Pugliese, 2016). In a social context, students are able to dialogue with peers at a similar or higher knowledge level, which Vygotsky said helps students grasp concepts more quickly than if the students were working on their own.

Bandura believed people learn by watching, imitating, and modeling the behavior of others in a reciprocal fashion (Bandura, 1977) and said that most of the information that we consider valuable in life is authored and imparted socially (Bandura, 1986). In his social learning theory, Bandura (1986) said, "Modeling that effectively conveys abstract rules of judgment improves children's reasoning skills" (p. 486). Much of our learning happens through modeling, and those modeling behaviors require attention, memory, and motivation (Bandura, 1986). Social learning can happen in a classroom environment during group work, discussion, debates, and so forth, or outside of the classroom in various ways (Bandura, 1977). The inherent design of adaptive learning courseware involves interaction between the student and the adaptive learning system (Pugliese, 2016). However, adaptive courseware could be implemented in a

variety of curricular designs, some of which could include social interaction (Brown, 2015; Y. Yang et al., 2014).

Experts and Novices

Another way to look at cognitive development is to examine how experts learn and apply their knowledge compared to how novices learn. Novices consciously think about each element of what they are to do (Felder & Brent, 2016). Experts, however, "have a mental library of situations and reactions to them and so execute most steps automatically, devoting their conscious attention only to unfamiliar situations that call for decision making and action" (Felder & Brent, 2016, p. 190). Experts learn much more quickly in their subject area than novices do, and this discovery led researchers to want to learn how experts make their learning processes more efficient (Kellman, 2013). Early research in the study of expert knowledge began with DeGroot and his study of master chess players as he sought to learn how experts were able to consistently win at chess. The study uncovered that master chess players were able to use meaningful patterns to consider appropriate moves and their consequences quickly (Bransford et al., 2000; Kellman, 2013). Bransford et al. (2000) highlighted several key differences about experts' knowledge. The authors said, "Experts have acquired extensive knowledge that affects what they notice and how they organize, represent, and interpret information in their environment. This, in turn, affects their abilities to remember, reason, and solve problems" (Bransford et al., 2000, p. 31). Experts are able to notice meaningful patterns and use them to solve problems quickly in a wide variety of contexts (Kellman, 2013). They are able to retrieve relevant information with little effort because they have organized their knowledge into conceptual structures or schemas that shape how they conceive of and respond to different problems (Bransford et al., 2000). Prince (2004) said that it is necessary for experts to have both

a broad and deep foundation of factual knowledge in their disciplines. The ability to retrieve relevant information with little effort is a desirable outcome of learning (Kellman, 2013). Sawyer (2014) applied the expert model and the experts' creation of mental models to the field of science, describing the outcome as "understanding about how to go about doing science, combined with a deep knowledge of models and explanatory principles connected into an integrated conceptual framework" (p. 7).

Experts learn new things by actively creating mental structures or schemas that they can apply to various situations (Sawyer, 2014). Sawyer (2014) indicated that constructivists believe that any learning resembles what experts do—create mental structures. He said, "Constructivists posit that learning involves the active creation of mental structures, rather than the passive internalization of information acquired from others or from the environment" (Sawyer, 2014, pp. 24-25). Because of the complexity of the mental structures, novices have difficulty constructing them on their own (Sawyer, 2014). The cognitive apprenticeship model describes how expert understanding can be taught to novices. Cognitive apprenticeship is a phenomenon by which experts guide novices in learning the knowledge, processes, and skills needed to do something the expert knows or does (Abbott, 2008; Brown, Collins, & Duguid, 1989). Using the cognitive apprenticeship model, the expert would take the novice through the stages the novice must go through in order to become an expert (Abbott, 2008). The process would resemble this: the expert would show the novice the big picture, walk the novice through the process of how to deal with the subject or issue, show the novice how to break the subject or issue into small bits, have the novice practice the small bits, and then teach the novice how to join the bits together. Through this process, the novice learns the larger concepts, the language, the facts and smaller bits of knowledge, and the process of how it all comes together. Proponents of cognitive

apprenticeship purport that this kind of learning results in deep and thorough understanding of the concepts and processes (Abbott, 2008).

Cognitive apprenticeship falls under the theory of situated cognition, which emphasizes that people's "knowledge is situated, being in part a product of the activity, context, and culture in which it is developed and used" (Brown et al., 1989, p. 32). Situated cognition emphasizes social aspects of learning that occur when students are interacting, discussing, and sharing knowledge with others while completing activities or tasks and solving problems together (Learning Theories, 2017). A similar theory, situated learning theory, claims that the environment is a relevant factor that influences learning (Lave & Wenger, 1991; Nathan & Sawyer, 2014). According to the situated learning theory, learning is embedded or situated within the activity, context, and culture in which it occurs (Learning Theories, 2017). Expert learning and cognitive apprenticeship methods of learning require experts to guide the learning process (Abbott, 2008; Kellman, 2013).

Experts are people who have been able to create deep and broad learning of factual and conceptual knowledge (Prince, 2004). Deep learning has a lasting and meaningful effect and is therefore desirable, as opposed to surface learning which is rote and superficial (Houghton, 2004). Fink (2003) indicated that significant, deep learning may not require cognitive apprenticeship, but it does require active learning. Fink said active learning can lead to significant learning if it is designed in such a way that the student attains information and ideas, does something with that information by applying it to an activity or experience, and then reflects on the learning that occurred through verbal or written means.

Attaining deep, expert knowledge is enhanced by a collaborative approach to learning involving expert guidance and occurring in real-life situations in the appropriate environment

(Abbott, 2008). This approach is "inherently mediated by social interaction, including the use of language" (Sawyer, 2014, p. 25), but it can also occur through indirect and online settings (Fink, 2003). Burbules and Bruce (2001) found dialogue to be a very effective means for developing deep understanding. Dialogue can occur in online environments in the form of online discussions. Online discussion forums provide a venue for deep, reflective writing with an opportunity for social interaction (Farquhar, 2013). Farquhar (2013) found that including dialogue was a way to decrease the sense of distance in online courses. So and Brush (2008) found that student satisfaction increased when classroom learning designed for collaborative and social learning was combined with online instruction. Dialogue plays an important role for growth and developing deeper knowledge, for both students as well as those working in a particular field of study. For example, scientists today construct knowledge through collaboration with peer scientists to test hypotheses and debate concepts by engaging in dialogue with other experts (Sawyer, 2014).

Learning Effectiveness

Faculty members guide the development of deeper, higher order thinking in their students through the questions they pose and the learning activities they give to students (McKeachie & Svinicki, 2006). In the 1950s, Bloom developed a taxonomy which has been widely used in education that helped articulate higher and lower order thinking skills within the cognitive domain (Krathwohl, 2002). There are six levels in the taxonomy, ranging from lower order thinking skills of knowledge, comprehension, and application, to higher order thinking skills of analysis, synthesis, and evaluation. In 2000, Anderson and Krathwohl revised Bloom's original taxonomy to incorporate what they believed to be skills for the new millennium. They changed the nouns to action verbs and reordered two higher order categories. The revised taxonomy

includes remembering, understanding, applying, analyzing, evaluating, and creating (Krathwohl, 2002). Bloom's taxonomy, both the original and the revised versions, are used frequently as instruments for measuring lower order and higher order thinking and are often referenced by faculty members and course designers when crafting learning objectives and assessments. Bloom's taxonomy is often used in creating and categorizing course learning objectives, which form the basis of what is to be learned in the course (Wiggins & McTighe, 2005). Content and assessments are aligned to the learning objectives (Quality Matters, 2015).

When designing course content and assessments, course designers and faculty members take into consideration how students approach learning and the processing of information (Quality Matters, 2015). Kolb identified four ways of approaching learning new things and labeled them learning styles (Patton et al., 2016). To Kolb, everyone has a preferred learning style that influences the manner in which they learn new things (Kolb, 2015; Miettinen, 2000). Depending on learning style, a student may learn better by engaging in hands-on experimentation with a new concept, reading well-articulated theoretical descriptions of the concept, observing and reflecting on it, or discussing the concept with a peer (Patton et al., 2016). Kolb (2015) built on ideas of several theorists to create a holistic experiential learning theory. This cyclical four-stage theory included concrete experience, observation and reflection (perception), abstract conceptualization (cognition), and active experimentation (behavior; Patton et al., 2016).

Study of the brain and the development of cognition has provided greater insights into understanding how people learn, and these insights have informed the practice of teaching (Sawyer, 2014). How the student perceives his or her learning effectiveness also impacts the success of the educational experience (Patton et al., 2016). Self-efficacy refers to the strength of the student's belief that he or she can do the task (Alt, 2015). In the 1960s, developmental

theorist Nevitt Sanford found that students need to be challenged at a level that does not exceed their perceptions of what they are capable of learning and yet surpasses their present level of knowledge. Successful completion of a task bolsters the student's self-esteem. Sanford said the amount of challenge a student can tolerate is dependent upon the amount of support the student believes he or she has (Patton et al., 2016). Educational psychologist Jerome Bruner referred to this as scaffolding, such that when students are presented with new and challenging tasks, they are also given more structured instruction and support in order to help them rise to the next level of understanding (Angelo, 1993). Faculty members determine the structure of the instruction during the course design stage prior to the start of a course (Gagne et al., 1992; Quality Matters, 2015). Designing courses that scaffold learning and provide additional instruction at the beginning of a new topic with opportunities for students to practice their understanding and receive feedback from others helps students correct misconceptions and contributes to students' sense of efficacy, motivation, and success in a course (Angelo, 1993; McKeachie & Svinicki, 2006). Adaptive learning systems are designed around the concept of challenge and support and utilize scaffolding to provide additional content or even hints to support student learning (Pugliese, 2016).

The design and integration of teaching strategies, content, learning activities and experiences, and assessments, known as curriculum design, is a key factor in the efficacy of education (Fink, 2003). The next section examines elements of curriculum design.

Creating the Environment for Learning: Curriculum Design

Curriculum refers to "the means and materials with which students will interact for the purpose of achieving identified educational outcomes" (Ebert et al., 2013, para. 1). It can also mean anything from learning objectives, to educational materials, to assessments. It may refer to

a standardized or purchased curriculum package, such as a math curriculum, but it often refers to lesson plans and materials developed by the individual teacher designed specifically to meet the needs of the current students ("Curriculum," 2015).

Course Design

The planning, design, and development of a course occurs during the course design stage, before the course starts. In the course design stage, faculty members or instructional designers write the course objectives and plan the instructional materials, teaching strategies, assignments, and ways of assessing students (Gagne et al., 1992; Quality Matters, 2015). Instructional design is a systematic way to design instruction based on the knowledge of how people learn. Designing a course or a learning unit involves analyzing the students, identifying learning outcomes, developing the instruction, and planning how students will be assessed (Gagne et al., 1992).

Wiggins and McTighe (2005) coined the concept of backwards design to describe how they approach the design of a course. In this conceptualization, the faculty member first considers what students should learn by the end of the course—the learning outcomes—and then builds backwards from there with specific learning objectives, content, and practice activities to create a system that allows students to gain the knowledge and skills necessary to attain the intended outcomes (Wiggins & McTighe, 2005). The authors posed the question, "How do we make it more likely—by design—that more students really understand what they are asked to learn?" (Wiggins & McTighe, 2005, p. 4). Using the backwards design approach helps course designers target and focus instructional planning on the end goals—the intended learning outcomes for the course (Wiggins & McTighe, 2005).

Fink (2003) incorporated the backwards design model into a process he said leads to significant learning. In Fink's (2013) design process, faculty members first consider the situations impacting their students in the particular course and then design the course with the end goals in mind. They incorporate assessments and feedback that help students learn as they progress through the course and provide teaching and learning activities that have students actively using and reflecting on what they are learning (Fink, 2003). Finally, the model states that faculty ensure that all of the elements of the design are aligned and integrated cohesively (Fink, 2003).

Several approaches are inherent in designing instruction that faculty members or instructional designers may employ to engage students in learning (Gagne et al., 1992). Information-based content consisting of facts, concepts, principles, and procedures is well suited for an information-processing model (Joyce & Weil, 1996; Richey, Klein, & Tracey, 2011). Information-processing models focus on intellectual development as well as acquisition and processing of concepts and language. However, if the focus of instruction is on guiding student behaviors toward predetermined objectives, a behavioral model may be preferred (Joyce & Weil, 1996). Joyce and Weil (1996) said the behavior model structures learning activities in ways that guide students toward ideal behaviors. Social interaction models of course design are based on a premise that humans learn best in social settings and through modeling behaviors and social exchanges (Bandura, 1977; Bandura, 1986; Joyce & Weil, 1996). Behavioral and social interaction models of instruction can address the application of verbal and motor skills as well as procedural, factual, and conceptual knowledge (Richey et al., 2011). Personalized models of teaching focus on individual students creating, directing, and structuring personal meaning in their learning and are often associated with self-esteem, self-efficacy, and self-actualization

(Joyce & Weil, 1996; Saskatchewan Education, 1991).

Adaptive learning is often associated with personalized learning because the system adapts content and delivery to the personal needs of the student (Fleming, 2014; Pugliese, 2016). Adaptive systems assess student prior knowledge, provide new content to fill knowledge gaps, and reassess students and are well suited for aiding in student attainment of discreet facts and application to broader concepts (Pugliese, 2016). Different disciplines and course goals lend to differing models of instruction (McKeachie & Svinicki, 2006). For example, students in applied music courses may be taught with a behavioral model, whereas students in a western civilization course may be taught with an information processing model, and students in an interpersonal communication course may be taught with a social interaction model (Kolb, 2015).

A few of the course design models serve as examples that faculty members and course designers employ to seek to provide guidance and consistency to the process of designing a course. At their core, these models outline the process of planning and designing instruction and assessing what students have learned in a manner that helps lead students to the attainment of the course learning objectives and deep learning (Fink, 2003; Quality Matters, 2015; Wiggins & McTighe, 2005). They apply to the designing of a traditional classroom-based course, a course delivered online, or an adaptive learning course (Fink, 2003; Quality Matters, 2015; Wiggins & McTighe, 2005).

Teaching Strategies

Within the instructional models, instructional strategies are applied to meet the individual learning needs and styles of the students (Joyce & Weil, 1996). Instructional strategies commonly include direct instruction, indirect instruction, experiential learning, independent study, or interactive instruction (Fink, 2003; Joyce & Weil, 1996; L. Wilson, n.d.; Saskatchewan

Education, 1991). Courses based on lecture, text, or inquiry are common teaching strategies (Fink, 2003), reflecting the information processing model (Joyce & Weil, 1996; Kolb, 2015), although courses could be designed around group work, technology enhancements, skill development, or a combination of techniques (Bransford et al., 2000). Other teaching strategies include simulation, case studies, problem-based learning, role playing, and debates, to name a few (Kolb, 2015). Instructors can choose from a wide variety of technologies for delivering content and instructional activities; however, the aim of the technology should be to support the attainment of student learning objectives (Heinich, Molenda, Russell, & Smaldino, 1999; Quality Matters, 2015).

Course Implementation

Course implementation, also called course delivery, consists of all the activities and interactions that the instructor does in order to help students learn once the course begins. Student activities and faculty interactions are planned during the course design stage and implemented during the delivery stage (Quality Matters, 2015). Chickering and Gamson (1987) provided several principles that help to define good practice in the delivery of undergraduate education. Those principles encourage communication, respect, and cooperation between faculty member and student as well as between and among students. Active learning, time-on-task, timely feedback, and high expectations were also recommended (Chickering & Gamson, 1987). Angelo (1993) added that faculty members can help focus students' attention by drawing out what the most important concepts are from the many details, similar to the cognitive apprenticeship concept. Angelo also stated that faculty help students connect new knowledge to what they already know, or in some cases, to unlearn false conceptions and come to know valid new material.

Recalling what learning scientists have discovered about how people learn, course design and delivery strategies should include ways to have students recall prior knowledge, provide foundational facts and conceptual knowledge, guide students in constructing mental schemas of their knowledge, and have students define their own learning goals and monitor their learning progress (Bransford et al., 2000).

Course Modality

One element that impacts course implementation is the modality in which the course is to be delivered (Heinich et al., 1999). Course modality refers to the mechanism by which courses are delivered and typically consists of either face-to-face, online, or a blend of both (Cavanaugh, 2012). After examining the needs of their students, educators may elect a traditional face-to-face classroom environment in which to offer courses, particularly if the institution draws traditional-aged college students who live on campus (Clark & Mayer, 2016), whereas institutions that primarily serve non-traditional students who work or do not live near campus may elect to offer more online courses (Cavanaugh, 2012). Online courses can be delivered synchronously or asynchronously. Asynchronous learning has no simultaneous interactions, whereas synchronous learning includes simultaneous interactions such as live web-based conferencing in which the entire class participates in a class lecture or discussion or communicates live with each other. The delivery mode of a course shapes instructional strategies (Clark & Mayer, 2016). Faculty members must consider what delivery modes are suitable for the courses they teach and what strategies can best help students attain course learning objectives (Fink, 2003).

Online. Approximately 28% of all students take at least one online course (Allen & Seaman, 2016). For students who have restrictions on their time or abilities to attend classes on campus, online courses provide flexibility and convenience to allow them to continue their

education, take an extra course, and balance other commitments (Cavanaugh, 2012).

While the presence of online education is growing, concerns exist regarding how well online learning meets the needs of students (Allen & Seaman, 2016). In 2016, less than 30% of chief academic officers indicated their faculty accepted online learning as valuable and legitimate. Clark (2005) argued there was no significant difference in the learning outcomes of students in courses that were delivered using technology and those that were not. In a meta-analysis of studies on online, blended, and face-to-face learning outcomes, online and face-to-face courses were very comparable, and blended learning outcomes fared slightly better than both the other two modalities for delivering education (Means et al., 2010).

Focusing students' attention and building upon their existing knowledge present added challenges in an online environment that must be intentionally addressed by the faculty member. For online courses, faculty members determine when, what topics, and how often they engage in interactions with students and whether those interactions are made with the entire class or with individual students (Clark & Mayer, 2016). These interactions are part of the faculty member's presence within the online course (D. Garrison, Anderson, & Archer, 2000). In 2000, D. Garrison et al. first developed a framework called the Community of Inquiry which highlighted and considered the intersection between teaching presence, social presence, and content presence. R. Garrison and Arbaugh (2007) indicated that in the delivery of an online course, teaching presence is a "significant determinant of student satisfaction, perceived learning, and sense of community" (p. 163). Teaching presence consists of the instructional design and organization of the course done prior to the start of the course; the facilitating discourse that the faculty member leads, such as raising questions or making observations to push students to think more deeply about a subject; and direct instruction, which is done through sharing subject-matter

knowledge and analyzing student comments for accurate understanding (D. Garrison et al., 2000). In later iterations of the framework, researchers identified that students' primary social priority is to have a shared social identity and sense of purpose of the course. This involves the faculty member defining the terms by which students identify with the class, building a sense of trust with and among students, and establishing means by which students can develop interpersonal relationships (D. Garrison, Anderson, & Archer, 2010).

A study of four million students looked at confounding variables impacting academic performance, such as personal, family, and institutional variables (Shea & Bidjerano, 2014). This study found that students at a higher risk of failing were taking online courses in greater numbers. When looking deeper at the data, researchers found that although students were performing up to 10 percentage points lower in online courses than in face-to-face courses, they were more likely to complete their degrees if they took online courses than if they did not (Shea & Bidjerano, 2014). Were they not taking online courses, they likely would not be taking any courses at all because of their personal, work, or financial circumstances. Those students needed the flexibility of online courses in order to progress toward their degree (Shea & Bidjerano, 2014).

Research has suggested that certain situational variables and personal traits lead students to greater success in online courses (Colorado & Eberle, 2010; Kauffman, 2015; Kerr et al., 2006). Students predicted to be successful in online courses often have characteristics of self-direction and self-regulation, internal motivation, technical aptitude, and high self-esteem and sense of self-efficacy, and are goal and achievement-oriented (Colorado & Eberle, 2010; Kauffman, 2015; Kerr et al., 2006; Pintrich & De Groot, 1990). Studies have also indicated that students should have high academic preparation, including reading and writing skills, in order to

be successful in online courses (Kerr et al., 2006).

Online courses require more explicit organization and structure such that students can follow the organization and understand what is expected of them without the real-time guidance or clarification typically offered by the faculty member in an on-ground course (Gagne et al., 1992; Quality Matters, 2015). Online faculty members and course designers may employ design principles and guidelines such as Quality Matters, Rubric for Online Instruction, or other guides developed by their institutions to ensure clear course structure. Instructional design principles help faculty and designers systematically design courses based on knowledge of how people learn (Gagne et al., 1992; Quality Matters, 2015). Course design practices hinge on articulating learning objectives, aligning content and learning activities to help students attain the objectives, and providing students with numerous opportunities for feedback on their learning (Gagne et al., 1992; Quality Matters, 2015; Wiggins & McTighe, 2005). These course design principles apply to online, blended, and flipped courses (Clark & Mayer, 2016).

Blended learning. Blended learning generally refers to courses that are designed with both online and in-person learning experiences ("Blended Learning," 2013) in which some of the normally scheduled classroom time is replaced with online learning (Sener, 2015). In some cases, researchers have found increased learning outcomes in blended learning over completely online courses (Means et al., 2010; Zhao, Lei, Yan, Lai, & Tan, 2005). A key factor leading to learning outcome gains centered on faculty involvement (So & Brush, 2008; Zhao et al., 2005). Learning outcomes were higher when faculty members engaged with the class and lower when the course was completely pre-produced (Zhao et al., 2005). So and Brush (2008) found that course structure, emotional support, and the method of communication positively impacted students' perceptions of satisfaction and social presence in blended courses. Course design also

had implications on learning effectiveness in blended courses. Lim and Morris' (2009) findings suggested that incorporating higher order thinking into the design of blended courses could positively influence learning outcomes. Student interactions with computer systems in the online portion of blended learning can also have a positive or negative effect on student learning and satisfaction (Zhao et al., 2005). Zhao et al. (2005) noted that student learning was positively impacted when the system prompted students to assess their knowledge or set goals for what they intended to learn.

Flipped learning. Flipped learning modality refers to a course design model that uses active learning practices in the classroom and content delivery through online means prior to class time, thus flipping the traditional model of content delivery during class and homework assigned for outside of class. The flipped design incorporates active learning and student engagement into the classroom (Educause, 2012) and requires that students take a more active and self-directed role in their learning (Boharty, Redford, & Gadbury-Amyot, 2016). Boharty et al. (2016) found that course grades of students taking a flipped course improved over students taking the course in a traditional lecture mode, but student and faculty satisfaction dropped. White et al. (2014) found that students in flipped classes may be reluctant to participate in classroom learning activities if the activities are passive or if students do not perceive the activities as adding to their learning. Students also may not have the maturity or development to be ready for active learning that requires them to initiate their own learning. Successful implementation of flipped learning design involved attention to the physical learning environment, the interaction patterns among the students, and the quality of the engagement in learning within the classroom space (White et al., 2014).

Active learning classroom. Active learning classroom is a term used to describe

classrooms designed for student-centered, active, collaborative learning (Baepler et al., 2016). The classrooms typically have round or "D" shaped tables to seat small groups of students complete with computer display capabilities and white boards for each table. There is no front of the room or lecture space for the faculty member, but the room is instead designed for the faculty member to roam around the room guiding and coaching students learning in groups (Baepler et al., 2016).

Beichner (2014) found that combining both curriculum improvements and classroom re-design configurations can improve learning outcomes. A problem-based or project-based curriculum design for learning in groups is often used in active learning classrooms (Beichner, 2014). "Teams of three students work on interesting problems, take measurements or make observations, or write computer models of physical phenomena" (Beichner, 2014, p. 15). When the curriculum and the learning space are integrated as active learning classrooms, Baepler et al. (2016) found four key findings related to the relationship between space, teaching, and learning. Those findings were that students in active learning classrooms (ALC) achieved better academic performance than students in traditional classrooms, students in ALCs surpassed grades predicted by standardized tests, students experiencing active learning pedagogical methods in an ALC achieved significant learning gains over students in traditional lecture-based teaching in an ALC, and using flipped and blended models in an ALC can compensate for reduced face-to-face class time (Baepler et al., 2016).

Technology-enabled active learning. A pedagogical model built on the concept of active learning classrooms incorporates technology as a key element of its design. Technology-enabled active learning (TEAL) incorporates media-rich software simulations and visualizations in specially redesigned classrooms made to facilitate collaborative learning (Dori & Belcher,

2005). Dori and Belcher (2005) studied undergraduate students and the impact the TEAL model had on their cognitive and affective outcomes and found students had significant gains in conceptual understanding and students in the small-scale implementation would recommend the course to other students. The project was conducted with a control group and a small- and large-scale experimental group. Students in the large-scale implementation had both positive and negative perceptions of the course (Dori & Belcher, 2005). Outcomes of the TEAL model vary when course design and delivery are not a key focus (Shieh, Chang, & Liu, 2011). Shieh et al. (2011) studied cognitive and affective outcomes of students in a general physics course using the TEAL model a few years later and found that students in the experimental group using the TEAL model earned grades 11% higher than the control group in the first semester of the study; however, the learning gains were only 1% higher than the control group in the second semester of the study. Student comments pointed to teaching styles and instructional skills of the faculty member, as well as student prior knowledge, study habits, and cohort atmosphere, as impacting student outcomes (Shieh et al., 2011). Innovative technology and active learning classrooms alone do not lead to significantly better outcomes but are driven by curricular design and pedagogical practices that integrate with the features of the physical space and the technology enhancements (Heinich et al., 1999; Quality Matters, 2015; Shieh et al., 2011).

Theoretical Framework:

Collaborative Learning and Social Development

While technology-based learning has continued to develop in sophistication, several learning theorists argued for the need of humans to learn with other humans (Bandura, 1977; Brown et al., 1989; Collins, Brown, & Newman, 1987; Lave & Wenger, 1991; Vygotsky, 1935/1978; B. G. Wilson & Myers, 2000). Collaborative learning is the term used to refer to

college students learning knowledge such as critical thinking, argumentation, and the construction of new knowledge through interaction with each other (Bruffee, 1995; Kyndt et al., 2013). A goal of collaborative learning is to help people learn and work on substantive educational tasks together (Bruffee, 1995). Bruffee (1995) indicated that collaborative learning cultivates interdependence between learners, and it presumes both a certain knowledge and authority level. Bruffee described the knowledge level as that which is above the foundational knowledge such as objective facts and the authority level that presumes that students have a level of intellectual maturity to assume a level of control and autonomy over their learning. In collaborative learning, Bruffee said that knowledge is constructed socially in small groups, tested among a larger community within the classroom, and then evaluated by the professor representing the larger professional community.

Roschelle and Teasley (1995) defined collaboration as "a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (p. 70). They differentiated it from cooperative learning, which they said was "work accomplished by the division of labor among participants, as an activity where each person is responsible for a portion of the problem solving" (Roschelle & Teasely, 1995, p. 70). Others have not made this distinction. Johnson, Johnson, and Smith (2007) and Johnson and Johnson (2009) used the term cooperative learning when speaking of college students working and learning together on a substantive educational issue. Johnson and Johnson (2009) said underlying theory behind cooperative learning is the social interdependence theory, first developed by Duetsch and expanded by David Johnson and Roger Johnson. In the theory, positive interdependence exists when people perceive that they would be able to reach their personal goals when others they are working with could also reach their goals. The individuals,

in turn, help each other by promoting the other's efforts (Johnson et al., 2007). Effective cooperation, according to the social interdependence theory, develops under conditions of "positive interdependence, individual accountability, promotive interaction, social skills, and group processing" (Johnson et al., 2007, p. 23). In cooperative education, self-interest is expanded to "mutual interest through other people's actions substituting for one's own, through an emotional investment in achieving goal . . . , and through an openness to being influenced so that joint efforts are more effective" (Johnson et al., 2007, p. 17).

Johnson et al. (2007) analyzed over 168 studies in a meta-analysis, and results suggested significant and substantial increases in verbal, mathematical, and procedural knowledge acquisition.

> Cooperative . . . tends to result in higher achievement, greater long-term retention of what is learned, more frequent use of higher-level reasoning (critical thinking) and meta-cognitive thought, more accurate and creative problem-solving, more willingness to take on difficult tasks and persist (despite difficulties) in working toward goal accomplishment, more intrinsic motivation, transfer of learning from one situation to another, and greater time on task. (Johnson et al., 2007, p. 19)

The study also indicated collaborative learning had positive impacts on social and relational aspects and personal self-esteem and psychological health (Johnson et al., 2007). Similarly, Folkestad and DeMiranda (2000) found that collaborative learning fostered higher order thinking skills in which students also applied value thinking and judgment. Collaborative learning also required students to discover, share, and use knowledge rather than just retain and regurgitate it on tests. Clayton, Blumberg, and Auld (2010) conducted a study of 132 undergraduate and graduate students studying psychology in two public New York City colleges. One of their

findings suggested that social aspects of learning are connected to greater engagement and better learning.

While Duestch and Johnson and Johnson (2009) primarily examined the implications of social interactions, relationships, and motivation in the social interdependence theory, Vygotsky (1935/1978) studied underlying cognitive development to explain the effects of learning with others. Vygotsky (1935/1978) said, "Human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them" (p. 88). Vygotsky studied the development of children as a means of understanding broader human development and wrote of the interrelation between learning and development. Piaget was a contemporary of Vygotsky, and Piaget's stage theory of development dominated the approach to educating children at the time—namely, that biological development must occur before learning could occur (Vygotsky, 1935/1978). Vygotsky (1935/1978) did not agree, and through experimentation and dialectical writing argued that learning preceded development, stating "the only 'good learning' is that which is in advance of development" (p. 89).

A key element of Vygotsky's (1935/1978) social development theory was the zone of proximal development, which was defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). Vygotsky (1935/1978) said that "learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers" (p. 90). Therefore, he believed social interaction is a catalyst to learning and cognitive development. Learning, when well structured, can set a variety of developmental processes in motion that could not occur without learning

(Vygotsky, 1935/1978). To illustrate Vygotsky's theory, consider a student who first learns some information when exposed to new ways of conceptualizing a topic or problem and is working toward understanding it fully, but at the moment does not have complete understanding at a mastery level. If the student were to receive peer or teacher support, the student may be able to use the information at a higher level than the student could do without the support of more knowledgeable others to guide him or her. The difference between what the student can do with others and by himself or herself is what Vygotsky called the zone of proximal development. The student, when assessed alone, would be assessed at a lower level. However, the student is in the process of developing greater understanding and will later achieve that understanding (Vygotsky, 1935/1978). This research brings to light the concept that once initial foundational mastery is accomplished, it provides the basis for subsequent development of more complex thinking. For this reason, Vygotsky believed that cognitive development processes lag behind learning processes. Cognitive development is described as "a complex dialectical process, characterized by periodicity, unevenness in the development of different functions, metamorphosis or qualitative transformation of one form into another, intertwining or external and internal factors, and adaptive processes" (Vygotsky, 1930/1978, p. 73).

Vygotsky (1935/1978) believed instruction and learning precede cognitive development in children. Both play and school instruction create a zone of proximal development because in both, "children elaborate socially available skills and knowledge that they will come to internalize" (John-Steiner & Souberman, 1978, p. 130). Vygotsky's social development theory highlighted the notion of interpersonal (social) learning processes initiating an internal developmental process and the role of more capable peer learners. Vygotsky viewed learning as

a social process which emphasizes dialogue and the role language plays in mediating cognitive growth (John-Steiner & Souberman, 1978).

Moll (2014) said that Vygotsky took a cultural and historical approach in his views of human learning and development. "We fashion our nature through the mediation of others—through the appropriation of culture and its resources, which change through history" (Moll, 2014, p. 1). Therefore, Moll concluded that Vygotsky viewed people's education as central to what they were, who they were, and what they could become.

While Vygotsky saw learning as a social catalyst of cognitive development, Lave and Wenger (1991) viewed social learning as impacting societal and generational learning. Lave and Wenger wrote of the place of observation in learning, and they developed the concept of legitimate peripheral participation that refers to the way new people are brought into the community and grow to full participation in the community. Lave and Wenger's work spoke of the importance of learning within a social context and speaks to a societal level of learning that may span generations.

In a smaller and more immediate context, Bandura (1977) theorized that learning is behavioral, but also a cognitive process which takes place in a social context in which people can learn by observing others. The general premise behind Bandura's (1977) social learning theory was that it emphasized the "prominent roles played by vicarious, symbolic, and self-regulatory processes in psychological functioning" (p. vii). Additionally, he said that "human thought, affect, and behavior can be markedly influenced by observation, as well as by direct experience, fostered development of observational paradigms for studying the power of socially mediated experience" (Bandura, 1977, p. vii). Bandura's social learning theory was primarily focused on

broad individual and societal learning, such as individual behaviors learned by young children through observing others and the responses they get through their behaviors.

Bandura's (1977) social learning theory included four main premises: reinforcement, punishment, reasoning, and modeling. Behavior reinforcement can take place vicariously through observing the consequences of others' behavior (Grusec, 1992). Bandura devoted considerable attention to the development of the fourth premise, modeling, which stipulated that young people learn by observing others through modeling others' behavior and the consequences that follow (Grusec, 1992). His four-stage process of observational learning included attention, retention, reproduction, and motivation (Bandura, 1977). Lippe and Becker (2015) applied Bandura's observational learning process in a study to measure nursing students attitudes and perceptions of competence following a simulation activity and found increased student outcomes. Kim, Smith, and Thayne (2016) indicated that social contexts impact learning—specifically motivation, self-efficacy, and affect.

Brown et al.'s (1989) cognitive apprenticeship theory had similarities to Bandura's (1986) observational learning theory. Cognitive apprenticeship points to the need for students to be guided by an expert through the use of the tools and the language of the discipline and guided through the practices—just as a craftsperson would have guided a new person learning a craft (Brown et al., 1989; Collins et al., 1987). There are six teaching methods involved in cognitive apprenticeship. The process of cognitive apprenticeship starts with the teacher or the expert modeling and describing the practice, then moves to the students doing the practice with the expert coaching the students through it, and ends with the students performing the practices independently, while the expert remains available to assist if needed (Brown et al., 1989; Collins

et al., 1987). The learning ends with reflection and evaluation on what was learned (Collins et al., 1987).

Brown et al. (1989) highlighted the role and importance of the social and collaborative aspects of cognitive apprenticeship:

> The social network within the [student] culture helps develop its language and the belief systems and promotes the process of enculturation. Collaboration also leads to articulation of strategies, which can then be discussed and reflected on. This, in turn, fosters generalizing, grounded in the students' situated understanding. From here, students can use their fledgling conceptual knowledge in activity, seeing that activity in a new light, which in turn leads to the further development of the conceptual knowledge. (p. 39)

Applying theory to practice involves an interpretive state (Moll, 2014). In cognitive apprenticeship, the expert helps the novice interpret the situation, language, and culture of the discipline to apply appropriately the theory, knowledge, and skills to the situation at hand (Brown et al., 1989; Collins et al., 1987).

In the concluding paragraphs of Collins et al.'s (1987) work, the authors suggested their hope for the future that personal computers would be able to implement the teaching methods they described—modeling, coaching, and fading in an apprenticeship style—forecasting what adaptive learning and intelligent tutoring systems are starting to emulate.

Computer-aided instruction emphasizes information acquisition (Clark & Mayer, 2016), and virtual systems are able to simulate some authentic practice with the tools and language of the discipline that Brown et al. (1989) referenced in their work on situated cognition. Situated cognition theorists state that learning needs application in a setting—more specifically a

disciplinary culture—using the language and tools of the discipline. Brown et al. described approaches to teaching math that exemplified situated cognition and contrasted with more traditional models of presenting theory, formulas, and procedures for solving math problems. In one example, the instructor presented a concrete situation with which the students would all be familiar and posed an increasingly complex series of problems that required the students to use their intuition, existing knowledge, and perceptions to come up with the solutions. Brown et al. referred to the problem-solving activity as an authentic activity. In the exercise, the instructor asked guiding questions to help lead the students to the correct answer and, in doing so, helped them to develop cognitive processes like those used by expert mathematicians. The instructor "led from students' implicit understanding of the world beyond the classroom, through activity and social construction in the culture, to the sort of robust learning that direct teaching of algorithms usually fails to achieve" (Brown et al., 1989, p. 38). After the students understood how to solve problems surrounding the very concrete example with which they were familiar, the instructor gradually introduced them to the standard algorithms used to calculate the answers to the questions she had posed. By providing the instruction and guiding learning in this fashion, the instructor was able to help the students develop a thorough grasp of how the algorithm was constructed, what it calculated, and how it could be applied to real-life situations (Brown et al., 1989).

As Brown et al. (1989) explained, situated cognition promotes the use of concrete examples set in situations with which the students are familiar. Once students are able to apply the new knowledge and problem-solving abilities to something with which they are familiar, they are then able to develop more easily an understanding of the more abstract concepts that are generalizable and can be applied more broadly to many settings. Through situated cognition,

students use their implicit understanding of a situation and then socially construct new ways to solve problems through an authentic activity using the cognitive processes of one in the discipline (Brown et al., 1989). Situated learning, cognitive apprenticeship, social learning, cooperative learning, and collaborative learning all involve humans interacting, communicating with, and learning from other humans. The next section adds the element of technology to the design of learning environments.

Flipped Learning

The advances of instructional technology to capture and deliver video content online at a low cost has led to growth in the use of instructional video (Davies, Dean, & Ball, 2013). The concept of flipped teaching and learning reached considerable attention over the past several years since Daniel Pink (2010) wrote of the "new buzz word sweeping the US" (p. 1) called flip. The Flipped Learning Network (2014), a non-profit online community organized for the study and application of flipped learning, developed a formal definition of flipped learning:

> Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and are involved creatively in the subject. (para. 2)

Four basic premises that define the flipped model include dedication to a flexible environment, learner-centered approach, well-designed and intentional content that aligns with learning goals, and commitment of instructors to observe students and provide feedback actively (Flipped Learning Network, 2014).

There are many approaches to the flipped learning model (Bergman & Sams, 2012; Flipped Learning Network, 2014; Sams, 2011; Stanciu, 2016). One key element is that students

study content outside of class (Educause, 2012), which may consist of readings, online text-based and video content, simulations, quizzes, and group or individual activities (H. G. Anderson et al., 2017; Davies et al., 2013; Sams, 2011). The use of videos is common and may include screencasts, how-to tutorials, and video lectures for remediation and re-teaching as a means of filling students' gaps in understanding. Course design may be based on self-paced learning, inquiry-based learning, or mastery learning (Sams, 2011). In mastery learning, an established level of performance—as measured by formative assessments—must be met before students can advance to the next unit of instruction (Guskey, 2010). In-class time may be dedicated to working on assignments, remedial exercises, problem sets, class or group discussion, group work, case studies, think-pair-share, problem solving, tests, experiments, or activities targeting higher order thinking (H. G. Anderson et al., 2017; Davies et al., 2013; Strayer, 2012).

Many researchers have conducted studies on the effectiveness of the flipped classroom model to compare academic performance, student perceptions, and student satisfaction of flipped classroom methods compared to traditional lecture-based methods (H. G. Anderson et al., 2017; Bohaty et al., 2016; Davies et al., 2013; Sahin, Cavlazoglu, & Zeytuncu, 2015; Strayer, 2012). H. G. Anderson et al. (2017) conducted a study in which 78 students registered for a pharmacy calculations course were randomly assigned to either a lecture-based model or a flipped model of the course. The lecture-based model consisted of a reading assignment to be completed before class, lecture and instructor modeling or examples given during class, and homework to be completed after class. The flipped model had preparatory work that consisted of one or more activities including recorded lectures, reading assignments, group activities, or individual activities (H. G. Anderson et al., 2017). The flipped model in-class activities included group and individual readiness tests, brief lecture and modeling activities to prepare for active learning, and

active learning consisting of one or more of discussion, group case studies, guided note taking, problem sets, simulation, and think-pair-share. After class, students completed a reflection activity (H. G. Anderson et al., 2017). Both versions of the course were taught by the same teachers on the same day and used the same course materials, examples, and problem sets. Anderson et al. found that students in the flipped pharmacy calculations course performed better on exams at both six weeks and six months into the course than students in the lecture-based version of the course. Students in the flipped course also performed better on a standardized test after six weeks than students in the lecture-based course (H. G. Anderson et al., 2017).

Bohaty et al. (2016) found that students in the flipped model were required to take a more active and self-directed role in their learning, and course grades improved over students taking the course in a traditional lecture mode. Sahin et al. (2015) studied the academic performance and perceptions of 96 students taking a college calculus course in either a flipped or lecture-based model. They found that students in the flipped course achieved significantly higher quiz scores than the students in the lecture-based course. Additionally, 83% of the students in the flipped course stated that the flipped lessons better prepared them (Sahin et al., 2015).

Other researchers have primarily focused on student perceptions and satisfaction (Al-Zahrani, 2015; Khanova, Roth, Rodgers, & McLaughlin, 2015; Telford & Senior, 2017; Zeren, 2016). Al-Zahrani (2015) compared a flipped course and a lecture-based course in a quasi-experimental design and found that students indicated that the flipped course promoted greater creativity, fluency, flexibility, and novelty than the lecture-based course. However, students believed they were not prepared for the flipped method of learning and would have benefitted by advanced preparation in using the technology and understanding the methods (Al-Zahrani, 2015). Telford and Senior (2017) found that students liked the convenience, variety, and control

they had in a flipped course and that they needed and valued in-person instruction and wanted to have a balance between face-to-face and online learning. Zeren (2016) said that flipped courses promoted independent learning, critical thinking, greater problem solving, better engagement, and intrinsic motivation.

To summarize, flipped learning emphasizes active application of new knowledge in the classroom with immediate feedback and evaluation of performance from peers and instructors (H. G. Anderson et al., 2017; Sams, 2011). Students can benefit from interacting with others to solve problems, articulating their ideas, receiving shared knowledge of others in the class, practicing what they are learning, and receiving feedback on their work (Sams, 2011; Zeren, 2016). However, careful attention must be paid to the design and planning of the content, pre-course activities, and in-class activities to engage students and ensure alignment with learning objectives (Bohaty et al., 2016; Khanova et al., 2015). Otherwise, both student and faculty satisfaction may drop (Bohaty et al., 2016).

Successful implementation of flipped learning requires preparing the students for the methods and technologies to be used in the flipped model (Al-Zahrani, 2015). Students should be good at managing their time, be self-directed, and have some motivation to complete the pre-work before class, yet instructors must be cognizant of not overloading students with out-of-class work (Al-Zahrani, 2015; Khanova et al., 2015). Students in flipped classes may resist participating in classroom activities if they do not perceive the activities as adding to their learning or if they see the activities as passive (White et al., 2014). Faculty members should take an active role in engaging students in active learning in the classroom and emphasize application of knowledge and the use of critical thinking skills in classroom activities (Al-Zahrani, 2015; Khanova et al., 2015). Flipped learning requires the instructor to pay careful attention to the

selection and design of content and in-class activities, the alignment of before-class and in-class activities, and the design of assessments to align instruction, activities, and assessments to the learning objectives (Khanova et al., 2015; Quality Matters, 2015; Wiggins & McTigue, 2005).

Adaptive Learning

Adaptive learning systems are being applied in higher education contexts with some early positive impacts on learning outcomes and retention (Bowen et al., 2012; Dziuban, Moskal, Cassisi, et al., 2016; Lovett et al., 2008; Y. Yang et al., 2014; T. Yang, Hwang, & Yang, 2013). In this section, adaptive learning will be explored, including its roots in cognitive science, recent outcomes, and implications to teaching and learning.

Adaptive learning refers to an instructional technique as well as a technological tool (Fleming, 2014). As an instructional technique, adaptive learning adjusts instruction to meet the level of understanding of the student. Good teachers do this all the time—they ask students questions in order to assess students' current understanding and misconceptions and then provide correction or new information to help expand the students' understandings (Brown, 2015). Adaptive learning, as a tool, attempts to emulate that instructional technique with technology, and can do so on a much larger scale (Brusilovsky, 2003).

In the research literature, many different terms exist that describe adaptive systems that have overlapping functionality (Brusilovsky, 2003; Magnisalis et al., 2011; C. Wilson & Scott, 2017). Brusilovsky (2003) wrote of adaptive and intelligent web-based systems that included adaptive hypermedia systems and intelligent tutoring systems. Adaptive hypermedia adapts the presentation of content and the navigational support to meet the needs of the student whereas the intelligent tutoring system sequences the curriculum, uses artificial intelligence to analyze solutions, and provides problem-solving support to the students (Brusilovsky, 2003). Magnisalis

et al. (2011) differentiated between adaptive systems, which present content or provide navigational support tailored to individual learning styles and needs, as compared to intelligent tutoring systems, which rely on artificial intelligence and modeling of domain-specific problem solving. Recent research trends involve bringing together the attributes of these systems, some labeling the combined concepts computer-supported collaborative learning (CSCL; Magnisalis et al., 2011). C. Wilson and Scott (2017) proffered to label them Course Assembly System and Tutorial Environment. Others are merging the capabilities under the term adaptive learning (Brown, 2015; Pugliese, 2016).

When designing instruction, teachers or instructional designers analyze the students and their anticipated prior knowledge (Gagne et al., 1992; Wiggins & McTighe, 2005). Once a profile of a typical student is conceptualized, then teachers or instructional designers determine the desired learning outcomes, develop instruction to convey new knowledge, and then plan how the students are to be assessed in order to measure whether the outcomes had been attained (Gagne et al., 1992; Quality Matters, 2015). Designing adaptive learning requires much the same conscientious planning (Pugliese, 2016). The designers identify baseline understanding, articulate desired outcomes, stake a learning path, assess the state of knowledge after instruction, and then revise and reassess the next time the instructional unit is given (Dziuban, Moskal, & Hartman, 2016).

Adaptive learning systems are designed to adjust to each student's level of abilities in ways that accelerate the student's performance (Brown, 2015). They do this through interventions given by both the system and the instructor. The adaptiveness of the system is intended to account for differences among students' abilities and backgrounds (Pugliese, 2016). It measures what the student knows and then sequentially moves the student through the content

toward the predetermined learning outcomes and mastery levels (Brown, 2015).

At their core, adaptive systems of today consist of automated assessment and remediation processes, sequenced progression of skills, assessment of learning objectives, real-time collection and analysis of a variety of data, and an ability to self-organize and act upon the data that they collect (Pugliese, 2016). Several approaches are inherent in the underlying processes that determine how adaptive learning systems actually adapt to student performance (Brown, 2015). Four approaches are machine learning, advanced algorithms, rules-based, and decision tree (Pugliese, 2016).

Some adaptive systems are based on machine learning (Pugliese, 2016). Machine learning uses pattern recognition, statistical modeling, predictive analytics, and other capabilities to detect how individual students learn as well as to predict their mastery of the subject matter at any point in time. These systems develop unique profiles of individual students and customize the sequencing, pace, and type of content provided to the students based on the students' individual learning preferences and strengths or weaknesses, as demonstrated through their actions with the system (Pugliese, 2016).

A second type of adaptive learning system is based on advanced algorithms. These systems use prescribed learning paths based on different learning profiles (Pugliese, 2016). As students use the system, it collects and analyzes transactional data such as clicks, time between actions, and number of assessment attempts. The system compares each student's performance to data from other students and adjusts instructional methods and content in real time if the learning path is not proving effective for the student (Pugliese, 2016).

A third type of adaptive learning system uses rules (Pugliese, 2016). A rules-based system uses a pre-test to assess a student's entry level of competence before beginning a unit of

instruction. This assessment determines which of a set number of pre-determined learning paths a student will progress through (Pugliese, 2016). The path has static content and assessments. Ongoing feedback is given to the student on his or her performance, and the system may provide remedial instruction if the rules indicate it is appropriate based on the student's performance. Unlike the two previously mentioned systems, in the rules-based system, the learning path stays constant throughout the learning unit unless it is manually changed (Pugliese, 2016).

A fourth type of system is a decision tree. It uses a limited set of pre-determined content and assessments. The system is programmed using "if this, then that" branching logic. Content is provided to the student, and a student's answers to the assessments will trigger the next appropriate branch of content (Pugliese, 2016). Several developers of adaptive systems use any of the previously mentioned approaches. The approach determines the sophistication level at which the system will be able to adapt to the individual learning needs of the student (Brown, 2015).

Cognitive Science in Adaptive Learning

The study of cognitive science has informed the development of adaptive learning systems. New content delivered in small, sequenced segments allows students to process and synthesize new knowledge with pre-existing knowledge (Brown, 2015). Psychologist Jerome Bruner referred to this as scaffolding (as cited in Angelo, 1993). In adaptive learning, small chunks of content are designed to cover particular learning objectives. Students are asked to apply their knowledge by answering follow-up questions, and the questions that are provided also adapt to have students apply knowledge to different scenarios (Pugliese, 2016). Optimal learning takes place when students are challenged slightly above their current understanding. Vygotsky (1935/1978) referred to this as the zone of proximal development, and it is defined by

the difference between what students can do on their own and what they can do when they have help from others in a social learning environment. Adaptive systems can be designed to give help if the instruction that is given is outside of the student's zone of proximal development (Brown, 2015). The help that is given can provide additional scaffolding to help elevate the student's understanding, similar to what another student, tutor, or teacher would do, so that the student is then able to answer the question and meet the learning objective. Adaptive systems use a library of learning objectives or competencies (Pugliese, 2016). Each learning unit has prescribed learning objectives or competencies describing specific abilities or behaviors a student will be able to do upon successful completion of the unit (Pugliese, 2016; Quality Matters, 2015). The adaptive system also uses a method for measuring a student's prior knowledge in order to establish a baseline of competency and to tailor subsequent lessons to the student's optimal zone of proximal development (Pugliese, 2016).

Cognitive science has been used to develop adaptive learning systems for use in higher education settings (Brown, 2015; Lovett et al., 2008). In 2002, Carnegie Mellon University received a grant from the William and Flora Hewlett Foundation to create the Open Learning Initiative (OLI). This initiative allowed university experts in cognitive tutoring to apply their knowledge to create open online courses (Carnegie Mellon University, 2016; Lovett et al., 2008). What resulted was the development of courseware that applied learning science to the creation of digital course content and assessments carefully designed around learning objectives (Fleming, 2014). The use of web-based instruction allowed course designers to embed assessments into each segment of content to collect data on student's grasp of the content (Carnegie Mellon University, 2016; Lovett et al., 2008). The student's performance triggered cues, suggestions, or corrections that were pre-built into the system to guide the student's learning, and student data

collected by the courseware system were analyzed to identify student learning behaviors (Carnegie Mellon University, 2016). The system then responded to the student in ways intended to support the individual learning needs of the student. Data analysis informed course designers of potential areas for revision to the courseware. The data were also analyzed by researchers to improve understanding of how people learn (Carnegie Mellon University, 2016; Lovett et al., 2008).

Learning is complex and is impacted by many factors (Sawyer, 2014). Students' abilities to learn can be impacted by their emotions and perceptions of their own ability to learn the material (Patton et al., 2016). Researchers at Stanford University have been exploring the use of different types of prompts used in adaptive learning systems to encourage students at the point at which they struggle. The researchers are studying the impact the prompt interventions have on student persistence (Blumenstyk, 2014).

Empirical Studies in Adaptive Learning

Adaptive learning has been considered by some researchers to be a system that can serve to optimize learning efficiency (Dziuban, Moskal, Cassisi, et al., 2016; Lovett et al., 2008). It has also been considered a tool to support lower performing or remedial students (Fleming, 2014; Straumshein, 2016). The Bill and Melinda Gates Foundation funded a study called the Adaptive Learning Market Acceleration Program (ALMAP) from 2013-2015. In the study, 14 public two- and four-year institutions examined the use of adaptive courseware in 23 introductory and remedial courses over 2-1/2 years (Yarnall et al., 2016). The courseware used by the different institutions had been developed by a variety of vendors, and some of the adaptive courseware could be customized by the faculty member to align with course objectives and individual teaching style, but other courseware systems could not (Barshay, 2016). The

findings on the effect of the adaptive courseware were inconclusive. In introductory courses, 35% of students experienced learning gains, and in remedial math and English courses, 95% of students experienced learning gains (Yarnall et al., 2016). However, the results suggested no significant difference in course completion rates. More students at the two-year institutions indicated they were satisfied with the adaptive learning systems than students at the four-year institutions, with the majority of four-year students being dissatisfied with the system (Yarnall et al., 2016). This could point to a difference in the needs or expectations of the students in two-year and four-year colleges, or the results could be due to other variables inherent with the study. Further research is necessary to explore the reasons for this difference.

Brown (2015) pointed out that some adaptive systems are open, meaning faculty members can customize the content and assessments to meet their learning objectives, and others are closed and cannot be modified. Closed courseware can be problematic if course objectives and faculty teaching style differ from the fixed content and assessments included in the courseware (Brown, 2015). Yarnall et al. (2016) suggested that student grade performance can be affected, and faculty members and students can become frustrated when adaptive courseware does not align with course objectives and exams. Similarly, Griff and Matter (2013) found inconclusive results in their study of six institutions that were using the McGraw Hill Learn Smart adaptive system. They speculated that the Learn Smart adaptive system did not closely align with the course learning objectives. Strayer (2012) said that the adaptive system used in his study sometimes explained course concepts or procedures differently than the teacher did in class which made it difficult for students and the faculty member to make connections between the in-class and out-of-class instruction. Alignment of learning objectives, content, and assessments is a key element of course design effectiveness (Quality Matters, 2015).

Courseware should be closely aligned to course and faculty expectations of learning objectives, content, and assessments or be easily customizable (Quality Matters, 2015).

A study conducted by Bowen et al. (2012) had generally positive results. The researchers in this study examined student performance outcomes at six public institutions offering adaptive introductory courses in statistics. The researchers were also interested in seeing if adaptive learning courseware offered in a hybrid environment would generate equal student outcomes for students of all backgrounds and abilities. The study supported equal learning gains across all types of students, with no significant difference in grades between students who used the adaptive courseware and those who did not (Bowen et al., 2012). Interestingly, the findings indicated that courses using adaptive courseware that were hybrid and had fewer face-to-face instruction hours actually reduced the time students spent on the course by 25%. This meant that students could spend 25% less time on the course and achieve the same grade. Bowen et al. concluded that the adaptive courseware made learning the course content more efficient.

Instructors at Carnegie Mellon University used OLI-developed adaptive online courses to complement face-to-face courses. OLI researchers at Carnegie Mellon studied the effects of their statistics courseware on students. They found that students using just the online courseware achieved the same learning outcomes as the students who only attended classroom instruction with no courseware (Lovett et al., 2008). The researchers conducted another study to test the effectiveness of the courseware in an accelerated course. The same statistics course using the courseware was offered in an accelerated half-semester version coupled with two 50-minute face-to-face sessions per week (Lovett et al., 2008). Students who elected to participate in the accelerated hybrid course completed the same material with equal or better performance in half the time of the traditional course. Students in the accelerated course actually spent an equal

amount of time on statistics each week and finished in eight weeks instead of 16 weeks, thereby cutting the time they spent learning statistics in half. This study also supported the notion that adaptive courseware made learning more efficient in this circumstance (Lovett et al., 2008).

Dziuban, Moskal, Cassisi, et al. (2016) were interested in measuring not only learning outcomes but also student acceptance of the technology. They examined student perceptions of using an adaptive learning system for two online courses at the University of Central Florida. The study also looked at broader implications of adaptive learning on higher education. In this implementation of adaptive learning, students were given control of the pace of their learning and how much time they devoted to it. The results of their findings suggested that students perceived adaptive learning as generally positive, although they sensed an increase in isolation from the instructor and other students (Dziuban, Moskal, Cassisi, et al., 2016). The authors indicated that student criteria for evaluating satisfaction with adaptive learning were consistent with students' criteria for other learning formats, indicating that quality design, effective delivery and learning facilitation, fair and aligned assessment methods, and clear expectations led to student satisfaction (Dziuban, Moskal, Cassisi, et al., 2016; Kauffman, 2015; Quality Matters, 2015). Their findings also suggested that data gleaned from the adaptive learning system were an effective early predictor of student success in the course and may supplant the need for external predictive analytics systems that many institutions are adopting. Predictive analytics systems use algorithms to analyze student data, such as grades, high school grade point average, standardized test scores, and financial data. The algorithms are designed to predict future student performance, such as getting a D or F in the course (Dziuban, Moskal, Cassisi, et al., 2016). Dziuban, Moskal, Cassisi, et al. highlighted broader implications of the use of adaptive learning as having the potential to shift markedly a long-standing hallmark of formalized education, that

being the strict time structure of fixed term start dates, term lengths, and synchronous final exam periods. This de-emphasis or potential elimination of the academic calendar, they argued, has the potential to shift how many institutions structure their institutional cycles and processes (Dziuban, Moskal, Cassisi, et al., 2016).

Faculty response to adaptive learning has varied (Blumenstyk, 2014; Dziuban, Moskal, Cassisi, et al., 2016; Lovett et al., 2008; Yarnall et al., 2016). In the ALMAP study, half of the 23 instructors participating in the study elected not to use the adaptive learning courseware again (Yarnall et al., 2016). Researchers in the study concluded that because approximately two-thirds of students at the four-year institutions rated the system less than satisfactory, the instructors were not interested in using it again. Researchers in that study also indicated that the adaptive courseware, which had been developed by a variety of companies, may not have been well implemented or supported at some of the participating institutions, which may have contributed to less-favorable opinions (Yarnall et al., 2016). In contrast to the ALMAP faculty participants, Thille, a faculty member at Stanford—formerly at Carnegie Mellon University OLI—indicated that she did not like to teach without adaptive learning courseware (as cited in Blumenstyk, 2014). Her circumstances were very different from those of the ALMAP faculty in that she was a primary developer of the courseware she was using, and she was able to configure and use the system to meet her needs and teaching style. To Thille, the advantage of using the adaptive courseware system was that it gave her analytical data on her students to provide a rich picture of their activities and performance in the course, which in turn benefitted her in teaching them (as cited in Blumenstyk, 2014).

How an adaptive learning system is incorporated into the design of a course and what learning goals the system is expected to address are important factors of the learning

environment. Studies suggested that the way adaptive learning is incorporated into the design of the course impacts student learning outcomes and satisfaction (Griff & Matter, 2013; Lovett et al., 2008; T. Yang et al., 2013; Yarnall et al., 2016). T. Yang et al. (2013) studied the effects of an adaptive learning system being employed in a course designed to take learning styles and cognitive styles of the students into consideration. Students using the adaptive system scored better than students who were taught in a traditional method (T. Yang et al., 2013). Another study aimed at measuring critical thinking and content-area knowledge in a course that used adaptive learning found positive results (Y. Yang et al., 2014). Y. Yang et al. (2014) designed a blended and adaptive course based on three levels of student proficiency in English and incorporated instruction and learning activities on critical thinking, including Socratic questioning and debates. The course combined social interactions through debates in online discussions, critical thinking exercises employed through content adapted to three different levels of proficiency delivered online, and direct instruction in the classroom (Y. Yang et al., 2014). Students expanded their English language and critical thinking skills based on findings from pre- and post-tests, and students improved their language scores on standardized tests following the course. The researchers highlighted each course design element and how it contributed to the increase in student learning (Y. Yang et al., 2014).

The manner in which adaptive learning systems are implemented into the design and delivery of the curriculum can impact student learning outcomes and effectiveness (Brown, 2015). In a review of 13 adaptive learning systems developed for higher education, researcher Jessie Brown (2015) of Ithaca S+R concluded,

> It is our belief that as adaptive learning platforms begin to offer more instructor resources and course authoring tools they will become increasingly suited to blended contexts in

> which online learning, practice, and assessment are used to enhance—rather than replace—instructor explanation, intervention, and support. (para. 12)

Just as Means et al. (2010) found that blended learning models indicated better learning outcomes than traditional face-to-face or fully online courses, adaptive learning systems coupled with active and collaborative classroom learning may offer a highly effective instructional model of computer-enhanced learning, artificial intelligence, and classroom-based pedagogical practices (Brown, 2015).

Case Study Site

This research features a case study of a program designed to combine adaptive learning courseware with active and collaborative learning in the classroom. The case study site is a full-time, four-year graduate medical program at a medical school in the Western United States. The program enrolls nearly 300 students annually. There are three terms throughout the year—fall, spring, and summer—and students can be admitted during any term but typically enter in the fall. The institutional website indicates the program offers a learning environment that is student-centered and innovative, incorporating the latest equipment and ideas. Educational methods include traditional lecture, seminars, case-based learning, online modules, laboratory learning, clinical simulations, standardized patient exercises, direct patient care, and service learning.

One goal of the program is to emphasize inter-professional learning. As a strategy to try to meet that goal, the program is designed so that students collaborate with students in other health professions, such as optometry, osteopathic, and podiatric medicine. Another goal of the program is to provide students with early, direct patient-care experiences in order to provide a contextual reference for applying foundational knowledge and clinical skills the students learn in their courses. The curriculum had undergone a complete re-design recently during which the

modality was changed to a flipped learning model with active, collaborative learning in the classroom. The design of courses was changed to incorporate adaptive learning courseware for content delivery and objective assessment outside of class as a way to incorporate new technology to support learning.

Summary of Literature Review

Adaptive learning systems have demonstrated they have the potential to make student learning more efficient and increase learning outcomes (Bowen et al., 2012; Dziuban, Moskal, Cassisi, et al., 2016; Lovett et al., 2008). Adaptive learning systems are designed to adjust to each student's level of abilities in ways that accelerate the student's performance (Pugliese, 2016). These systems are designed to measure student prior knowledge, convey desired outcomes to students, establish an optimal learning path, gather metrics and evaluate a student's state of understanding, and remediate to fill knowledge gaps and reassess (Dziuban, Moskal, Cassisi, et al., 2016). Since adaptive systems are still relatively new, more research is needed to understand fully the educational benefits of adaptive learning. While several researchers have found that adaptive learning has increased learning outcomes and retention while maintaining positive student perceptions (Bowen et al., 2012; Dziuban, Moskal, Cassisi, et al., 2016; Lovett et al., 2008; T. Yang et al., 2013; Y. Yang et al., 2014), other researchers have found negligible differences in outcomes or lower student satisfaction (Coffin Murray & Pérez, 2015; Griff & Matter, 2013; Yarnall et al., 2016). Little research exists on student learning outcomes and experiences in adaptive courses utilizing a flipped learning model with active and collaborative classroom learning.

Vygotsky (1935/1978) said students learn sooner when learning with others. This points to a benefit for collaborative learning experiences. Fink (2013) said that deep, significant

learning requires active learning. Social interaction and collaboration can benefit student learning through engagement in shared inquiry and dialogue surrounding an intellectual pursuit (Burbules & Bruce, 2001; So & Brush, 2008; Vygotsky, 1935/1978). Adaptive courseware focuses on addressing student knowledge gaps through engaging students with content they do not yet know (Pugliese, 2016). Curriculum design that combines active and collaborative learning with adaptive learning could provide benefits of engaging with others and with technology that can adapt to individual instructional needs. My study is a case study which examines a program that has combined active and collaborative classroom learning with adaptive learning courseware using a flipped course model. In the study, I examined curricular design, faculty and student experiences and perceptions, and student learning outcomes in the program.

CHAPTER 3

RESEARCH METHODOLOGY

The purpose of this qualitative case study was to examine a case in which adaptive learning courseware and active and collaborative classroom learning are combined so as to learn faculty and student experiences, perceptions, and outcomes of this program design model and strategies. The findings may be beneficial to faculty members and academic program leaders interested in increasing student learning and exploring new curriculum designs. In order to gain these insights, it was important to conduct this case study.

Qualitative research takes place in a natural setting and takes a holistic view of an issue. It starts with assumptions and then applies a theoretical framework to help guide understanding of human perceptions of the problem (Creswell, 2013). In qualitative research, it is important to focus on relationships, settings, and occurrences to help explain behaviors (Hancock & Algozzine, 2006; Yin, 2011). Qualitative researchers explore complex contexts and collect a variety of data sources through rigorous and well-documented collection procedures (Creswell, 2013; Hancock & Algozzine, 2006; Merriam, 1998; Yin, 2011). Then, they conduct inductive and deductive analysis to determine patterns and themes. Specific themes are expanded to general themes using induction, and then generalizations are applied to specific situations using deduction. Qualitative research is written with fullness and richness, such that the reader experiences being there (Creswell, 2013).

The researcher is the primary instrument of data collection in qualitative research (Creswell, 2013; Merriam, 1998). The role of the researcher involves the use of positioning, and that role may be insider or outsider while collecting data (Creswell, 2013). Researchers use reflexivity to describe their position in the research study by conveying their background; this may impact how they interpret the data and what they hope to gain from the study (Merriam, 1998).

Case studies are bounded studies, such as the study of one institution or one program, and can include the study of one or multiple sites (Yin, 2011). The case could be intrinsic—unique—or instrumental in that it shares common features with other sites (Stake, 1995). Case studies seek to explore and describe the case in rich detail, including the history, chronology, and day-to-day depiction of activities (Yin, 2011). A case study involves developing in-depth understanding of the complexities of an issue in its particular context but limits generalizeability toward universal understandings for broad application (Bassey, 1999). Stake (1995) said that problems are not simple and clean, but rather, they are intricately wired to their social, political, and historial contexts and are attached particularly to personal contexts. In case studies, the researcher must draw out the underlying and inherent problems, conflicts, complexities, and compounding backgrounds that impact the human condition (Stake, 1995).

Merriam (1998) said that case studies allow for insight, discovery, and interpretation of a phenomenon. A case study can be defined as the process of carrying out an investigation on a unit of analysis—the bounded system or case being studied. Case studies are particularistic in that they focus on a particular program or phenomenon. They are descriptive, using rich, thick descriptions in the end product. They are also heuristic in that they can illuminate the reader's understanding (Merriam, 1998).

> The case study offers a means of investigating complex social units consisting of multiple variables of potential importance in understanding the phenomenon. It offers insights and illuminates meanings that expand its readers' experiences. These insights can be construed as tentative hypotheses that help structure future research; hence, case study plays an important role in advancing a field's knowledge base. (Merriam, 1998, p. 41)

Knowledge gained from case study research can be concrete, contextual, well developed, and generalized by the reader to other populations (Merriam, 1998).

Case studies include analysis of data to form themes that can present a simpler understanding of the complexities of the case that can then transcend the case (Yin, 2011). The meaning of the case is shared through assertions or lessons learned through analysis and interpretation (Crossley & Vulliamy, 1984).

> Case study need not be purely descriptive; it need not be limited to the micro-level; and it need not ignore comparative analysis itself. By focusing upon the complexities of educational practice, it can lead to important modifications of both educational policies and comparative theories of educational systems. (Crossley & Vulliamy, 1984, p. 204)

This study explored a program that was redesigned to incorporate advanced technology coupled with the very human side of social learning—active and collaborative learning among students in the classroom. The purpose of this qualitative study was to explore curriculum design and faculty and student experiences in a graduate program using a flipped course design model that incorporates an adaptive learning system coupled with active and collaborative classroom learning. The study reports common themes and patterns that emerged from the data collected. The study provides rich descriptions of several aspects surrounding faculty and

student experiences and perceptions about students learning with technology and students learning with other students.

Method of Inquiry

This study used a case study approach in order to gain a deep understanding and provide rich and holistic description of this program design and how it has been perceived by faculty and students. A case study serves to provide an in-depth understanding of a single case, issue, or problem with detailed descriptions and analysis (Creswell, 2013). Stake (1995) said that a case that can inform not only the case being studied but also other cases or situations is considered an instrumental case. This study was an instrumental case of a single program.

Purposeful sampling was used to select a program with a high demand for content-area knowledge that uses adaptive learning in conjunction with a collaborative and active classroom environment. A case study is not intended to prove something but rather to discover and understand through thorough exploration within the boundaries of a single case (Merriam, 1998). Qualitative research is guided by questions of process, such as how and why something happened, or of understanding, such as what happened and what does it mean for those involved (Merriam, 1998). The setting, the circumstances, and the thoughts and feelings of those involved are relayed in rich detail to help convey the essence of the case (Bassey, 1999; Creswell, 2013). The case study concludes with general lessons learned from the study of the case.

Research Questions

Using instructional design theory and social development theory, this study was designed to answer the following research questions:

1. Why and how was the design of the curriculum of a graduate medical program in the Western United States changed?

2. Have, and, if so, how have student outcomes in the graduate medical program in the Western United States changed following the curriculum redesign?
3. How do students and teachers describe their perceptions of and experiences with adaptive learning in the graduate medical program in the Western United States?
4. How do students and teachers describe their perceptions of and experiences with active learning and collaborative learning in the graduate medical program in the Western United States?

Selection of Program

This researcher, in an effort to identify leaders of adaptive learning in a flipped classroom environment, asked expert presenters at the 2016 Educause international conference who they would recommend consulting with regarding the application of adaptive learning in a flipped environment. Additionally, an adaptive learning research fellow at a higher education commission was asked who she would recommend speaking to regarding the application of adaptive learning in a flipped envirnoment. These researchers recommended speaking to an individual from an institution in the Western United States who was the visionary in redesigning a graduate medical education program curriculum to incorporate adaptive learning courseware outside of class and active, collaborative learning in class. Online articles and videos about the program were reviewed. This program was selected because it incorporated adaptive learning, which holds potential to increase human learning efficiency, and because this program implemented collaborative and active learning practices into the curriculum. The program consists of graduate-level medical students who are expected to gain broad and deep knowledge of medical concepts, facts, and procedures in addition to developing soft skills to be effective

practitioners. Because of the high demand for content knowledge attainment, application, and higher order thinking, this program type was desirable.

Selection of Participants

Other researchers described the individual responsible for creating the vision for the program which incorporated adaptive learning courseware outside of the classroom, paired with active and collaborative learning inside the classroom. The program visionary was a catalyst and driving force of the redesign of the program. This individual was featured in web pages and videos speaking about the program redesign, the goals of the new design, and his role in the change. He was interviewed in order to understand what elements were included in the program curriculum, why they were included, and how the program was organized. This individual was asked to recommend others to interview, thereby using a networking method of sample selection. The network method involves asking the individual being interviewed to recommend faculty members, staff, and students to interview. The program visionary recently retired from the program. He recommended interviewing the person who was responsible for implementing the full curricular redesign, who is refered to in this study as the director. The director recommended faculty members, staff, and students to interview. She was also asked to recommend names of individuals who have expressed both positive and negative aspects of the program. The goal of sample selection was to identify individuals who would provide a breadth and depth of both positive and negative experiences to enable a rich understanding of student and faculty member perceptions and experiences with a flipped learning environment that incorporates adaptive and collaborative learning. In an effort to understand student experiences in the program prior to the redesign, a list of all fourth-year students in the program were requested. The fourth-year students participated in the program both before and after the

redesign. Those individuals were emailed a three-question survey asking if they recalled the teaching and learning methods employed in the program and to rate how strongly the teaching methods contributed to their learning (strongly agree [5], agree [4], neutral [3], disagree [2], strongly disagree [1]). Lastly, they were asked if they would be willing to participate in a phone interview. The intent was that the first two to answer with a 3 on the scale would have been contacted to be interviewed. Those who answered that they were neutral would be more likely to have recalled both positive and negative aspects of the teaching methods of the program (C. D. Dziuban, personal communication, February 26, 2018). This purposeful sampling was intended to provide a variety of perspectives of the teaching methods used in the program. However, no fourth-year students responded to the requests to participate in the study.

Recruitment

It is important to interview individuals who have close familiarity with the program (Merriam, 1998). The director of the program redesign was asked to provide context and historical data, rationale for the redesign and methods chosen, and descriptive details about the program. This individual was the initial point of recruitment. The steps listed below outline the recruitment methods:

- The dean of the college serves as the gatekeeper to provide access to the site for performing the study. An email was sent to the dean of the college requesting approval to conduct a study on the program (Appendix A).
- An email invitation containing a link to an electronic "Consent to Participate" questionnaire delivered in Qualtrics was sent to the program director (Appendix B). Consent was delivered, collected, and stored in Qualtrics. A follow-up email was sent confirming her interest in participating in the study.

- The program director was asked to recommend faculty members and staff who have developed courses and have taught in both the old design and the new design of the program for interviewing.
- An email invitation containing a link to an electronic "Consent to Participate" questionnaire delivered in Qualtrics was sent to the faculty members and staff (Appendix B). Consent was delivered, collected, and stored in Qualtrics. A follow-up email was sent confirming their interest in participating in the study. Faculty members who gave consent for participating were asked if I could observe classroom activities of the faculty and students. Faculty members who did not give consent to classroom observation would have been sent a follow-up email thanking them for agreeing to allow me to interview them and acknowledging that classroom observations would not occur; however, all faculty members agreed to a classroom observation. After the faculty members consented to me observing the class, a follow-up email was sent thanking them for agreeing to allow me to interview them and observe their class.
- The program director was asked to recommend names and email addresses of current students in their first year and second year of the program to interview. One first-year and one second-year student were contacted by email and invited to participate. An email invitation containing a link to an electronic "Consent to Participate" questionnaire delivered in Qualtrics was sent to the students (Appendix B). Consent was delivered, collected, and stored in Qualtrics. A follow-up email was sent confirming their interest in participating in the study. Had any elected to not

participate, they would have been emailed a confirmation that there would be no negative repercussions because of their choice not to participate.

- A list of fourth-year students was requested from the college dean. Those individuals were emailed an invitation containing a link to an electronic "Consent to Participate" questionnaire delivered in Qualtrics (Appendix C). Consent data was delivered, collected, and stored in Qualtrics. Had there been any responses, they would have been analyzed in Qualtrics. Respondents would have been asked if they recalled the teaching and learning methods employed in the program and to rate how strongly the teaching methods contributed to their learning (strongly agree [5], agree [4], neutral [3], disagree [2], strongly disagree [1]). Lastly, they would have been asked if they would be willing to participate in a phone interview. Had any responded, the two earliest dated responses of a 3 on the scale would have been contacted for scheduling a phone interview. Had any respondents not been available for a phone interview, the next earliest dated respondent who selected the same answer on the scale would have been contacted for scheduling a phone interview. Following the interviews, the remaining respondents would have been contacted by email letting them know all necessary interviewing had been completed and thanking them for their interest in the study.
- Faculty members, staff, and students were informed that they would be able to withdraw from the study up to 24 hours following the interview by emailing this researcher or telling this researcher during the on-site visits.

Instrumentation

A semi-structured protocol was used for interview data collection. Semi-structured

interview protocols consist of a pre-defined list of interview questions that the interviewer used as a guide during the interview process (Yin, 2011). Interview protocols were used as prompts for interviews with the program visionary (Appendix D), staff (Appendix E), faculty members (Appendix F), students (Appendix G), and fourth-year students (Appendix H). Interviews were audio recorded. An observation sheet was used to record notes about observations (Appendix I). An artifact sheet was used to record descriptive notes and reflections (Appendix J). Pilot interviews were conducted with other educators and researchers in an effort to gain feedback on question wording, length, and number of questions. The protocol was reviewed by the dissertation committee.

Research Assistant

A research assistant who has completed classes in research methodology and holds a doctoral degree in instructional technology aided in the collection and analysis of data. The research assistant served to increase validity and reliability through having multiple researchers interpret and analyze the data. The research assistant completed CITI training in social and behavioral research and was trained in using the interview and observation protocols prior to participating in data collection and analysis.

Data Collection

Data included information gathered from interviews, documents, artifacts, and observations. Program data were collected from institutional documents, the program director, staff, and faculty. The first day of the site visit included a meeting with the program dean, a tour of the facility, collection of documents and artifacts, and general observations of the site. Interviews with faculty, staff, and students; additional observations; and collection of documents and artifacts were performed the remaining days of the site visit.

Interviews

"Interviewing is necessary when we cannot observe behavior, feelings, or how people interpret the world around them" (Merriam, 1998, p. 72). Students and faculty in the program were interviewed on-site using face-to-face, semi-structured methods to seek understanding of their experiences in the program. The subjects were instructed that their information would remain anonymous and that the researcher would assign a code to be used in place of their real names. A code list was used to track identifying information and will be held by only the researcher to uphold anonymity of individuals. The code list includes subject descriptions associated with each person's code. The subject's code was used in the research and reporting of data. An interview protocol was used to guide the interview processes. Interview protocols cover general topics and areas to be discovered and may—but do not necessarily have to—include questions to be asked verbatim (Yin, 2011). Rather, the protocol serves as a general framework to guide the interviewer in addressing each aspect needing to be covered in the interview (Yin, 2011). A separate interview protocol was used for each sub-group of interviewees—program visionary (Appendix D), staff (Appendix E), faculty (Appendix F), students (Appendix G), and fourth-year students (Appendix H). Interviews were audio recorded. The digital audio files were labeled with the subject's initials, the date, and location of the interview. The digital files were transcribed by a transcription company to text documents for analysis. The researcher's observations during interviews were typewritten after the interview.

Documents and Artifacts

Data were collected about the program design, implementation, and outcomes. Documents and artifacts consisted of information about the curriculum, design documents for the adaptive learning courseware, lesson plans for classroom learning activities, photographs of

classroom activity, some current and historical data on student learning outcomes and standardized test scores (pre- and post-redesign), and other documents or items the program visionary identified as important. Institutional personnel were asked to remove or block identifying information such as student names prior to them sharing the information. Documents and artifacts were recorded on the Document and Artifact Inventory (Appendix J), and any non-electronic materials were electronically scanned for analysis (Creswell, 2013; Hancock & Algozzine, 2006).

Observations

Observations conducted in field studies can offer a deeper understanding of social relationships and institutional settings and cultures (Yin, 2011). Observations in the field took place over four days. One first- and one second-year class of the program were observed to study the learning environment and students' learning behaviors of students who are fairly new in the program and students who are more experienced and have spent more time in the program. Observations of people, settings, and interactions in classroom activity and general hallway and campus surroundings were conducted. Faculty teaching in the active and collaborative classroom environment were observed. Classroom observations of students were conducted, but no personably identifiable data were recorded. Observations were gathered based on an observation protocol and recorded on the Observation Notes Form (Appendix I; Creswell, 2013; Hancock & Algozzine, 2006; Yin, 2011).

Data Analysis

There are several approaches that could be used in analyzing qualitative data. Ratcliff (2008) described a four-step approach. First, data are reviewed as a whole soon after being collected, and notes are made on big ideas, major themes, and unusual events or issues. Next,

the materials are read again, and the researcher marks issues, ideas, events, unusual elements, and key words with codes the researcher creates to denote main ideas. Next, the text is re-read and systematically coded to describe briefly the chunks of text; those codes are reviewed, and similar codes are combined into categories or themes. The last step involves creating connections between the themes, relating them to the research questions, and developing findings from the study (Ratcliff, 2008). Particular to case study research, Creswell (2013) recommended reading all materials and using minimalistic coding to keep within 25 to 30 codes and then distilling the codes and grouping them into approximately five to seven main themes. Key findings are then drawn from the themes, and a narrative is drafted to describe the case and its context in detail.

In this case study, observation field notes were recorded using the observation protocol on the day of the observation (Appendix I). Within one day of the observation or as soon as possible, field notes were reviewed and main ideas and unusual observations noted in the margins. Interviews were recorded electronically, and field notes were recorded immediately following the interview. Recordings were transcribed and then read as a whole. Summative notes were made to describe main ideas and note unusual remarks. The transcripts were then re-read and coded in Microsoft Word. A code structure was drafted that began to organize similar codes into categories or themes. A research assistant also read and analyzed the transcripts. The researchers compared analyses and made revisions based on considering the other's perspectives. The transcripts were read again, and codes were refined and similar codes collapsed as the researchers again compared their analysis. The code structure of themes and sub-themes was refined. Observations were compared to interview content, coded, and themed. Documents and artifacts were reviewed and analyzed for relevant descriptive information to provide richer

context and detail for the case. Any connections to interviews or observations were noted. Themes and sub-themes were refined based on document, artifact, and observation analysis, and researchers again compared notes. Themes, sub-themes, codes, and raw data were analyzed and discussed by the researchers. Findings and lessons to be learned from the case study were drafted. Finally, a detailed description of the case and its context was drafted.

Validity and Reliability

Ary et al. (2010) indicated that the terms validity and reliability, when used to refer to qualitative research, are better thought of in terms of credibility, transferability, dependability, and confirmability of the research study. Triangulating data sources, using multiple researchers to compare interpretations, and using reflexivity to control bias are some means to increase credibility of qualitative research (Ary et al., 2010). In this research study, multiple data sources were analyzed and findings compared for alignment between sources and with the literature. Negative case sampling was used to include participants who have differing perceptions. During interviews, the researcher bracketed or set aside personal experiences and suspended beliefs in order to hear subjects' experiences with a fresh perspective (Ary et al., 2010; Creswell, 2013). The primary investigator and a research assistant discussed and compared interpretations of data to increase dependability and confirmability of findings. Findings were also compared to the literature. A researcher's journal was kept to document actions and thoughts of the researcher during the data collection and analysis stages.

Ontologically, researchers of qualitative methods embrace the idea of multiple perspectives (Creswell, 2013). A limited number of interviews, backgrounds, prior experiences, and perspectives can lead to an increase in bias (Merriam & Tisdell, 2016). To reduce bias, the researcher should strive to continue collecting data until the same themes appear again and again

(Merriam, 1998). However, the ability to collect and report fully all of these multiple perspectives is limited by the available time, money, and ability to access all perspectives, as well as analyze and interpret them (Merriam & Tisdell, 2016). In this study, multiple perspectives were actively sought; however, observation and in-person interviews were limited to the allotted site visit and time available for the study.

Summary

The purpose of this qualitative study was to examine faculty and student experiences and outcomes in a program that has incorporated adaptive learning, which has the potential to increase the capacity of student learning, along with active and collaborative learning in the classroom, which social development theorists indicated enhance cognitive development. Knowledge gleaned may be useful for leaders of other programs in higher education, but results cannot be guaranteed. Generalization was not the goal of this study, but themes may provide strategies other institutional leaders may consider implementing within their programs. The findings of themes and lessons learned may help inform other program leaders and faculty members who are considering methods for enhancing student learning and outcomes in academic programs.

CHAPTER 4

FINDINGS OF THE STUDY

Information is produced at an increasingly rapid pace, and achieving a higher education has been viewed as a way to advance understanding and to improve career opportunities (Arum & Roska, 2011; Bastedo, 2016; Newman, 2003). However, lately higher education has been criticized for its ability to create knowledgable graduates with career opportunities (Arum & Roska, 2011). Pressures to demonstrate positive student outcomes have prompted college and university administrators to seek new ways of improving retention, graduation rates, grades, and other student learning outcomes (Middaugh, 2010).

Adaptive learning systems have demonstrated the potential to make student learning more efficient and to increase learning outcomes (Bowen et al., 2012; Dziuban, Moskal, Cassisi, et al., 2016; Lovett et al., 2008). Adaptive learning systems are designed to measure student prior knowledge, state desired outcomes, establish optimal learning paths, evaluate students' states of understanding, fill knowledge gaps, and assess knowledge gains (Dziuban, Moskal, Cassisi, et al., 2016). Some researchers have found that adaptive learning has increased learning outcomes and retention while maintaining positive student perceptions (Bowen et al., 2012; Dziuban, Moskal, Cassisi, et al., 2016; Lovett et al., 2008; T. Yang et al., 2013; Y. Yang et al., 2014), yet other researchers have found little difference in outcomes or have found lower student satisfaction (Coffin Murray & Pérez, 2015; Griff & Matter, 2013; Yarnall et al., 2016).

Vygotsky (1935/1978) said students learn faster when learning with others, pointing to a benefit of collaborative learning experiences. Through engagement in shared inquiry and dialogue surrounding an intellectual pursuit, social interaction and collaboration can benefit student learning (Burbules & Bruce, 2001; So & Brush, 2008; Vygotsky, 1935/1978). Adaptive courseware focuses on addressing student knowledge gaps through engaging students with content (Pugliese, 2016). Combining active and collaborative learning with adaptive learning could provide a learning environment that includes the benefits of engaging with others along with the advantages of using technology that can adapt to one's individual instructional needs. Little research exists on a curriculum design that uses a flipped model to combine adaptive courses with active and collaborative classroom learning.

The purpose of this case study was to research, analyze, and gain an understanding of a graduate medical program that was recently redesigned to combine adaptive learning courseware and active and collaborative classroom learning in a flipped model which has demonstrated early indications of success.

Research Questions

This study focused on the curriculum designed in a flipped model which incorporated adaptive learning outside of class and active and collaborative learning in the classroom. The case study examined the following research questions:

1. Why and how was the design of the curriculum of a graduate medical program in the Western United States changed?
2. Have, and, if so, how have student outcomes in the graduate medical program in the Western United States changed following the curriculum redesign?

3. How do students and teachers describe their perceptions of and experiences with adaptive learning in the graduate medical program in the Western United States?
4. How do students and teachers describe their perceptions of and experiences with active learning and collaborative learning in the graduate medical program in the Western United States?

Presentation of Case Study Data Sources

Experts in higher education and adaptive learning were asked for recommendations of programs that were using adaptive learning with early indications of success. Several experts recommended a program that was using adaptive learning with positive results. The graduate medical program in the Western United States was selected for the case study because the curriculum had been recently redesigned to use adaptive learning outside of the classroom and active and collaborative learning inside the classroom in a flipped model with initially positive results.

After permission to conduct the study was granted, following IRB protocols, a four-day site visit was arranged for conducting on-site interviews, site observations, and classroom observations. Classroom observations were scheduled based on availability of two courses, one first-year and one second-year, being taught in the same week in the fall of 2018. The two lead faculty members of those courses were contacted for interviews during the same week. An interview with another faculty member with significant experience in designing and teaching a course using the adaptive system was arranged during the same week. Interviews with a first-year student and a second-year student were arranged through the assistance of the program director. Students who had balanced views of the curriculum design and adaptive learning system were sought as participants in the study. The second-year student would have been a

member of the first class to have used the adaptive platform as the revised program was implemented. The first-year student would have benefitted by the revisions that were applied after the evaluation of the first year of using the adaptive platform. An interview with the lead instructional designer was also scheduled during the four-day site visit. The names of the individuals are not disclosed but instead are indicated by a code. Table 1 indicates the code used for each individual interviewed and the context surrounding that individual.

Table 1

Summary of Interview Participants' Roles and Contexts in the Program

Participant	Role and Context at Institution
FAC-1	Faculty member and course director for a first-year clinical dentistry course. This course was observed during the site visit. The faculty member has taught at the institution since the first day of class when the program started 12 years ago.
FAC-2	Faculty member and course manager for a second-year clinical dentistry course. This course was observed during the site visit. The faculty member has taught at the institution for five years.
FAC-3	Faculty member who developed and taught a course using the adaptive learning platform. She has taught at the institution for over eight years.
DIR	Program director and implementor of the first- and second-year clinical dentistry curriculum. She is also a faculty member.
VIS	Retired visionary of the redesigned program, faculty member, and administrator for the dental medicine program.
ID	Instructional designer who helped create the first- and second-year clinical dentistry program in the adaptive platform.
STU-1	Student in her first year of the dental medicine program.
STU-2	Student in her second year of the dental medicine program.

Each subject gave informed consent prior to participating in the interview. One 30- to 90-minute semi-structured interview was conducted with each of the participants listed in Table 1. Interview questions for the program visionary, director, instructional desiger, faculty members, and students were included in Appendix D, E, F, and G, respectively. Interviews with fourth-year students were sought; however, no students responded to the initial recruitment invitation nor the reminder email. Interviews with the first- and second-year students, the instructional designer, and two faculty members were conducted in-person during the site visit. The other three interviews were conducted by phone due to constraints of illness and schedules. The site visit also yielded data through observations of the campus and general conversations with administrators, faculty, and staff during a tour of the facilities.

First- and second-year clinical dentistry classes were observed during the site visit. The observations lasted three hours for the first-year class and 90 minutes for the second-year class. An observation protocol, included in Appendix I, was used to record observations and notes. The general site of the institution was also observed. Documents and artifacts relevant to the study were collected and recorded using the protocol in Appendix J. Specific names of individuals, programs, courses, and locations were substituted with generic titles or were redacted to protect confidentiality. Quotations were only altered for readability by correcting grammar and removing filler words such as "so."

Data collected from the case are organized and presented, first, to provide a rich description of the case and then to present the analyzed findings. The old and the redesigned curricula are described briefly, followed by a more detailed examination of how the curriculum was redesigned. The data collected from first-year and second-year classroom observations are presented. Next, findings on faculty and student perceptions and experiences are grouped into

three categories: flipped curriculum design, adaptive learning platform, and active and collaborative learning. Within each category, the findings are grouped into themes with supporting data. The last section highlights the preliminary outcomes of the program redesign. The presentation of the findings of this case study is intended to provide a condensed yet detailed view of the case relative to the research questions of this study.

Description of the Case

This graduate medical program focuses on dental medicine and preparing students to become dentists when they graduate. There were 66 dental schools in the United States at the time of the study (American Student Dental Assocation, n.d.). The case study program has been operating for approximately 12 years and features a dental clinic that is open to the public.

Program

The students in the dental medical program spend the first two years of the four-year program primarily in pre-clinical classes learning progressively advancing knowledge and skills in bio-medicine and a comprehensive dental curriculum. In the third and fourth years, students primarily practice their skills in a clinical environment on actual patients with perpetual self-evaluation, peer review, and faculty feedback and coaching. This study focuses primarily on the pre-clinical aspect of the program that recently implemented an adaptive learning platform for all content delivery, although other components of the four-year dental program are included to elucidate the broader context experienced by the students and faculty.

This dental program was intended to be innovative from the start. As FAC-1 described, "The goal of our founding dean . . . [was] to take traditional dental education [and] turn it on its ear." The faculty member added that the subsequent and current dean said that the "goal is to bring dental education into the 21st century." The current dean indicated that the institution

started with a blank slate, which meant this program would not be bound by the structures of traditional education. The intent was to do things better through innovative practices and technology with a goal of providing students with early and significant clinical practice. This desire to be innovative fueled redesigning the program to use adaptive learning technology.

Setting

The institution is set in an urban area with multiple buildings making up the campus. One building primarily houses the dental medical program, and it was originally built for this program. Across the street is a clinic for treating patients in the community. All courses for the dental program are held in the same building. A small cafeteria is in the building where students, faculty, and staff may get their lunch. Students and faculty were observed eating together, and faculty and staff mentioned that this was a common occurrence that contributed to a collegial environment and good rapport between faculty and students. The building has multiple floors filled with offices, classrooms, collaborative spaces, and other functional areas. Open spaces feature game tables; the dean mentioned that these were intentionally placed in areas for building commradery or relieving stress. Classrooms vary in size and layout. Small rooms are present for student groups to meet that feature a conference table and technology for sharing content.

The pre-clinical classroom is called the Simulation Lab and is specially designed for aspiring dentists. Each student's seat replicates a dentist's office, complete with a mannequin patient with a head that accommodates the plastic teeth sets that each student in the program has. A special dental chair is in place for the mannequin patient. There is also lighting, dental tools, sink, suction tube, and so forth. The large classroom easily fits all 69 students and is arranged in groupings of eight students clustered in two rows of four students, facing each other. Above the student groupings are large video monitors displaying a high-resolution view of a demonstration

or content shared from the instructor station. The instructor station at the front of the room is outfitted with the same type of mannequin and dental equipment that each student station has. The instructor station also has a camera on an articulating arm for close-up video of any demonstration given to the class. The demonstration can also be recorded and played back immediately.

Students

The students in the program are highly motivated with high expectations, according to administrators and faculty in the program. FAC-1 described the students as enthusiastic and eager to learn. He said, "They're here because they want to be here. They've worked hard and competed. I think there were 48 applicants for each seat in our Class of 2022. . . . With rare exceptions, these are students that are committed before they start." STU-1 said that students in the program "have always been hard on themselves because they've always wanted to get to this point" of being in dental school seeking an advanced professional degree. The students have a dress code following the American Dental Association guidelines which requires them to dress professionally and wear a white dental coat for their classes. FAC-1 mentioned this program was the only medical program at the institution with a dress code. Students interviewed mentioned they have seen a difference between students in their program compared to students in other programs. They said the students seem to act more mature and treat each other with more respect because of the dress code.

The students are required to have completed their bachelors' degrees prior to admittance into this program. They are primarily in their mid-20s to mid-30s and are mostly evenly split between males and females. Sixty-nine students are admitted in cohorts each year out of over 3,000 applicants, equating to about a 2% acceptance rate. By comparison, the American Student

Dental Assocation (n.d.) indicated that about 50% of applicants are accepted into dental school. Therefore, admission into this program is highly competitive.

Faculty

The faculty in the dental medicine program consists of two teams. One team works with the first- and second-year students in pre-clinical courses, while the other team focuses on coaching the third- and fourth-year students in the clinical environment. All of the faculty members have been clinicians at one point and can share their professional experiences with their students. The pre-clinical faculty members had demonstrated they were interested in dental education and teaching and learning, according to DIR.

Old Curriculum Design

Traditional dental education, according to some of the faculty members and administrators, consists of many courses organized by topic or by specialty that are taught in multiple-hour lecture format for the first two years of the dental program. According to VIS:

> The way it was taught traditionally is you would line up in these siloed courses and stay in a course for four, five weeks, then move to the next course. And by the time you were done at the end of two years, you couldn't remember what you did in the first or second course, let alone this 10th course. You had no way of tying this together in your mind and creating relevancy because you have never seen a patient in the clinic.

VIS said that there were many faults in the traditional model, which existed for 150 years. He highlighted that in the traditional model classes were siloed, meaning there were distinct separations between subjects. He also pointed to how students had to memorize a lot of information that was not integrated into something meaningful and current. VIS said that now, "when you have information that is doubling every 72 days . . . in a traditional four-year

curriculum, by the time the fourth-year student graduates, over 60% of everything they learned is obsolete already." VIZ said, "You have to know how to manage it [the information]. You have to know how to access it. That's a huge change. The old model is not at all interested in addressing that." He emphasized the need to be able to update the curriculum continually. "How do you keep up? That's an important question. How do you keep a curriculum modern, relevant, and up to date?"

Lecture had been the primary method of instruction since the inception of the program 12 years ago. The program instructional designer (ID) said the instructors were given a time slot, and they would lecture with PowerPoint slides about 98% of the time. A second-year faculty member (FAC-2) said that prior to the redesign, he would come into a class assuming the students did not know anything and that his job was to tell them everything they needed to know during the lecture. He also described the old model as siloed with limited opportunities for developing students' critical thinking abilities. The desire to improve kept program leaders searching for a better way to educate.

The new curriculum needed to be modern, agile, and flexible and help develop students' critical thinking abilities. The director of the pre-clinical program (DIR) and implementer of the redesign wanted to have a curriculum that was centered on patient care. VIS added, "We wanted online learning, classroom sessions—things like that—also, a competency-based education where they [students] can progress at their own speed . . . instead of sitting in lectures for 30 hours a week. We wanted to change that environment."

New Curriculum Design

In order to make all of these improvements, the leaders of the program envisioned a phased approach which started with the foundation of redesigning the organization of the

curriculum from siloed to integrated, followed by redesigning the delivery mode to use technology to deliver content outside of the classroom and active learning in the classroom.

The first phase of the redesign, which DIR said occurred in 2013, focused on making the curriculum patient-centered through scaffolded learning experiences that integrated various components in the curriculum. The integrated curriculum meant that the different disciplines and areas of speciality were combined and offered together each year. In each term of the program, learning was scaffolded such that students delved deeper into subject matter to advance their understanding of the complexities of dental practice and treatments. DIR said, "We wanted to introduce concepts in a more simplistic fashion and then come back to them again and again with increasing complexity." The dean explained that the program designers have intentionally covered the practice of dentistry holistically, having students apply the breadth of dentistry earlier in the program than most other dental programs. FAC-2 said that the intended outcomes for the program were for students "to gain more critical thinking, to have more working knowledge of the material, to assemble the pieces in a fashion where it was easier for them to recall and apply to patient care." FAC-2 described the new curriculum design from the student's perspective:

> The basic curriculum, it is broken down so there are no silos; it's broken down based off of a cycle of care for the patient. It starts out from a very generalized picture and spirals them to a very specific, granular detail. It starts with looking at the big picture with the patient, diagnosing, treatment planning, and then finally treatment, and the treatment slowly progresses from simple procedures to more complicated ones.

Implementing a new curriculum delivery model using advanced technology was the next phase of the redesign. The dean indicated this was a continuing evolution of an innovative

program. ID indicated that the dean wanted more engagement, not just sitting on the part of the students and not just lecturing on the part of the faculty. FAC-2 described the intent of using adaptive learning technology in the redesigned curriculum:

> The adaptive platform would allow each individual student to grow and progress at their own pace. The faster students would progress through it at an increased pace and then the slower students would take more time to go through the material. . . . I think that the main goal was to have the students enter clinic earlier.

To start redesigning the delivery model, some courses were piloted in adaptive technology in order to try out the adaptive platform and experiment with effective ways to present content and assess student learning. In 2017, the adaptive learning platform was implemented in the first year of the pre-clinical curriculum. DIR said the program was designed so that the students reviewed the information in the adaptive platform, then came to class for very active, hands-on learning. She described the classroom learning experience:

> They come and interact with it [what they learned on the platform] in a content reinforcement—play in the sandbox, so to speak, to borrow VIS's term—and then apply the information; ask questions of the discipline expert, of the faculty who prepared the content; ask questions of their peers—a lot of peer-to-peer learning; maybe do an assignment; maybe do a quiz or two; and then come back and review the content on the platform. Then maybe a month and a half or two months later, they have a written exam and all along the way they're being quizzed, so there's a lot of assessment.

Classroom time consists of students applying what they are learning and getting feedback from faculty. FAC-2 said his role as a teacher now focuses on helping students clarify understanding and apply knowledge:

> My assumption is now the students have already gone through the material. My job is to clarify any specific topics that were confusing on the platform and to do my best to [help] the students apply that knowledge and make that into a useful working knowledge or useful working memory.

Curriculum Redesign

The process of redesigning the curriculum took several years to accomplish. VIS said he was recruited to the program six years prior because of his vision to "marry a modern curriculum to the needs" of the students. He had experience in successfully creating or redesigning three other programs. The dean invited him to come to the institution in 2012 after the dental medicine program had been running for four years, as the first class of students was graduating.

VIS said he came to the institution, assembled a leadership team, and established a protocol for communicating and working together. He and the leadership team developed a shared vision that included active learning and flipped teaching. He also envisioned using technology to deliver content and provide detailed analytics of student activity and performance:

> I'd always been looking for an engine to be able to deliver a non-linear learning environment and build the interconnectivity of all the topics to each other, of all the disciplines—that's the front end. The back end of that engine . . . [generated] big data to monitor all, do all the analytics of what was going on in that environment. Everything from student performance, . . . to their behavior, to overall class grades, etc.

When VIS started at the institution, he believed it would take five years to implement the vision. He said the program had an existing curriculum in need of redesign and a faculty trained in a traditional manner of lecturing, which he hoped to change. He believed he could provide training and guidance to the young faculty and that he could "help them be successful while at

the same time completely redesigning this curriculum." Creating a shared vision among the leaders of the program was the first step, which took three or four months to achieve, VIS indicated. The next steps involved mapping the existing curriculum of about 35 courses and meeting with every faculty member to determine what would be taught in the new curriculum. Table 2 indicates the program redesign timeline.

Table 2

Timeline of Program Redesign

Year	Event
2012	VIS was recruited to the program; leadership team was built; vision was developed and shared; integration of curriculum across the disciplinary specialties began.
2013	Curriculum was integrated; prototype course was built in a flipped design delivering content online with active learning in the classroom; prototype course was offered to students.
2014	First course was built using adaptive platform and offered.
2015	First course in adaptive platform was offered for a second year.
2016	Second course was built in adaptive platform and offered; pre-clinical curriculum was mapped.
2017	First year of pre-clinical curriculum was built in adaptive and offered.
2018	First year pre-clinical curriculum was revised and offered; second year of pre-clinical program was built and offered.

Mapping the curriculum. Mapping the curriculum involved developing learning objectives and assessments and then organizing the content. The faculty members had to deliver a complete list of all the book chapters and topics for the content they taught. Then each faculty member had to break the chapters and topics down into specific pieces of content. This was time-consuming work. VIS described the process:

> A faculty member would come up to me with a title of this course and three or four chapters. Then, under each chapter would be one or two topics. That would cover 40 hours of a course. I would say, "Well, okay, this four-hour topic you have here, it's not really a topic. It's more of a title of what's four hours. Let's break that down." We went through that cycle until we got every single faculty to break down their entire class into 15-minute topics. For someone who had a 20-hour class, they had 80 topics. We put them all in Excel spreadsheets and recreated this big curriculum map out of that. That process alone took a year and the reason it did is because people are busy, obviously.

DIR worked with each faculty member on aligning their learning objectives and content, filling in gaps, or removing unnecessary content. The ID said that the program director would meet individually with each faculty member to review content and learning objectives, providing them feedback on content clarity and alignment. ID said the director would sometimes suggest that some content be eliminated or learning objectives be written or strengthened.

While mapping the curriculum, VIS said they "found lots of knowledge gaps of things that weren't being taught but had to be" for the program to remain accredited. VIS said their accrediting agency required 29 competencies be in their curriculum. He said that mapping the curriculum and breaking out the content for each topic and aligning it to the required competencies created a better curriculum.

> We were able to identify, say in a certain particular class, "you have to teach to these three competencies. Where are you teaching these and when?" We were able to tag those in our curriculum map and then . . . we'd see right away this visually that, gosh, this person isn't teaching this competency and at the same time, we're over redundant on the two competencies they are teaching to. In other words, we were able to really balance

out the importance and priority of all of the topics that the individual teachers were teaching.

VIS described, "By the first run through of starting to reconstruct it [curriculum], we opened up 400 hours in two years. If you can believe that, 400 hours of class time!" They reviewed and edited the content to refine and remove redundant information. "We did that a couple of times, but the result was now we had our very first working content map of all the relevant topics that all of the different disciplines had."

Integrating across disciplines. Once the faculty members and program leaders could see all the content pieces taught in the entire curriculum, then the next step, VIS said, was to rebuild it into an "integrated, multidisciplinary, systems-based approach." VIS explained that a dental practitioner must be proficient in a number of knowledge areas. In general practice, one patient may need a filling, a crown, or some gum work, while the next may need a different procedure. All of the content necessary to prepare one for dentistry was organized into six systems to align with the six semesters the students would take in their first two years in the program. During the first system, students would learn the basics. Each successive system would become more advanced, with the sixth system being very advanced. Students would work on virtual patient cases during each term. By the sixth system, students would be working on patient cases in which the patient would have multiple problems and be medically compromised. Students would have to "go through a complete diagnosis and treatment planning. They would make all kinds of decisions in all the different discipline areas to build a real positive outcome for that patient," VIS said. This formed the scaffolded approach to building knowledge and understanding in the students.

Once program leaders mapped the entire curriculum, they integrated and organized all of the content, combining similar content into succinct units. Then they sequenced the material to build student schedules. VIS said, "It takes a lot of hours just to build a schedule and schedule students and their times. You're working around other courses that they're taking and you're working with faculty." VIS said that they implemented it and it was quite successful.

Long-time faculty member in the program FAC-1 summarized the differences between traditional programs and this program's integrated curriculum:

> Traditional dental schools will teach the individual disciplines separately. . . . and we had to connect the dots between the disciplines. . . . but [in this program] we have them start doing fillings on the front teeth. They'll prepare a tooth for a crown—last week—and then follow up this week they started doing root canals on the front teeth, which is unheard of in the first year.

FAC-1 said the integrated curriculum benefits the students by giving them access to the material earlier in their program; "they're getting to know these teeth intimately, instead of having four or five separate courses that cover that material." It also allows for more repetition and review over the two years that the students are in their pre-clinical coursework. He added that the curriculum has been compressed as well: "These pre-clinical courses used to extend well into the third year when they're in clinic, and now once they're in clinic these courses are over. We've moved everything up to that extent."

Flipping the curriculum. In the next phase of the curriculum redesign, the flipped model was implemented with content delivered outside of the classroom on an adaptive learning platform. However, prior to implementing the adaptive learning system, VIS manually developed one course in a flipped design with content delivered through online PowerPoint

slides. He created this course as a proof of concept for future developments. In this prototype course, classroom sessions featured small-group, hands-on learning in which students worked in an immersive, active learning environment. They completed learning activities, worked with their peers, and applied the information that they had studied the night before. He confirmed that this learning environment provided students with a functional understanding of the content. "They knew how to apply all this didactic and esoteric stuff. It all revolved around cases and critical thinking and problem solving. They were able to take the anatomy they learned and actually apply it clinically." VIS determined that this model was effective:

> Prior to that, the students had been struggling with anatomy. The actual average grade was 68%, which is just a little bit below passing for an average class grade. Of course, there was a lot of remediation. I mean 20 kids would be remediated every semester. They were struggling on the national board exams. The very first year I ran this prototype, this beta class in a manual form, the average class grade was 83[%].

VIS said that the student scores increased 15% after he converted the class from lecture-based to a flipped classroom model with content and assignments completed outside of class and case studies, peer learning, and hands-on problem solving conducted in the classroom.

Converting the curriculum to the adaptive learning platform. The next stage of redesigning the curriculum involved converting content to the adaptive platform. The adaptive learning platform was incorporated into the curriculum gradually at first to test the usefulness of the system. VIS created his flipped course in the adaptive platform and ran it twice, in 2014 and 2015. VIS said the students would log onto the system, get their lesson plans, and study their materials. The students could choose whether they wanted to work alone, in teams, or in groups prior to coming to class. ID said, "That was our first full-on adaptive, fully flipped course model

where we did no lectures. It was all small group, all hands-on activities." They ran that course twice before expanding adaptive learning and the flipped course model to the next course.

In 2016, FAC-3 created a small portion of one of her courses in the adaptive platform. She found that her students preferred it, so she put all of the next course in the platform:

> I tried having part of the class—my course—delivered in the online platform, so I just did a section of one of my courses in the summer. Then, the rest of it was delivered in the lecture-based format that I always had been doing. I just wanted to see how they operated and what the students thought. Then they said they preferred the online adaptive learning to the lecture so they had something to compare against. The next year, I went for the whole class and . . . both courses were on the platform.

In the evaluations, students told her that they liked how they could control the pace of their learning and that, since time opened up in class, they could discuss what they were learning in class with peers and the professor. This positive feedback prompted FAC-3 to put all of the course in the platform the following year. She rethought the entire class using a content map and structured the course around learning objectives and assessments.

VIS said that by this point others in the program were starting to see and understand the vision. In 2016, DIR developed a framework to be used with the adaptive platform for the entire integrated pre-clinical curriculum, which included 25 faculty members and their discipline-specific content. The framework consisted of a hierarchical sequence of credentials, badges, milestones, and nodes. The categorical terms used in sequencing the curriculum are described in Table 3.

Table 3

Definition of Terms

Term	Definition
Curriculum	The entire pre-clinical program of coursework.
Credential	Coursework that, once completed, demonstrates competence in a specific domain; equivalent to approximately an 18-week term; there are six credentials in the pre-clinical curriculum.
Badge	Equivalent to a course; there are multiple badges per credential.
Milestone	Equivalent to a 60- to 90-minute lecture; there are multiple milestones per badge.
Node	Container for content, learning activities, and assessments organized into approximately a 15-minute unit for students to read and work through; there are multiple nodes per milestone.

VIS explained that he, DIR, ID, and the faculty broke the four-year program down into individual pieces of content they called nodes. The entire 3,000-hour program equated to 10,000 nodes. The nodes were clustered with similar content that built toward a general conceptual understanding, and each cluster was called a milestone. VIS gave an example of a milestone as "the function of dental pulp," and he stated that that milestone would probably consist of 10 or more nodes. Several milestones combined to make a badge. VIS explained that when students completed multiple badges in a sequence, they earned credentials. He gave the example of three badges—diagnosis and assessment, pathways of the pulp, and the health of the gums—that combined to equal a credential. Once students had completed the credentials, VIS said, "You [the student] can go in the clinic and you can work on a patient with that credential doing those procedures that you have been credentialed in." He added, "This is in the freshman year,"

meaning that, within their first year, students were able to complete credentials and go into the clinic to perform on real patients those skills in which they were credentialed.

VIS explained how students were motivated by being able to work with patients in a clinical environment early in the program. In the clinic, students experienced a real and tangible connection to the material they were studying and real-life settings in which to apply their knowledge and to see the results of their labors. VIS said that, as a student, "you're motivated. You're inspired to really plow through those nodes and milestones and earn those badges and get that credential because . . . you don't want to wait two years before [you] see [your] first patient." VIS said, "That provides motivation and inspiration to learn more, to be better at it. To come back and say, 'Now I know why I'm studying this stuff.'" The earlier clinical experience he attributed to the redesigned, integrated curriculum and the use of the adaptive platform.

After the program leaders developed plans for moving the entire two-year pre-clinical dental program to the adaptive platform, ID became the contact person for receiving course content from faculty and ingesting it into the adaptive learning platform. DIR developed a curriculum schedule that was used as a production schedule for developing the content in the adaptive platform. "I had a curriculum schedule we could work off of and that became our template," she said. "We have all these curricular topics that are scheduled a certain way because of the integration process. [The notion was] Let's go ahead and put them on the platform in a similar manner."

Converting the curriculum. In 2017, VIS said they started implementing the first year of the redesigned pre-clinical curriculum. ID said during the first year the curriculum was offered in the adaptive platform, the content consisted primarily of faculty members' PowerPoint presentations. She said the PowerPoint slides were ingested—imported and configured to fit the

platform—with some additional text-based explanations by the faculty members. The faculty members provided approximately three assessment questions for each node. DIR said that the production team was able to create about five milestones per week and about 20 milestones per month. It took approximately two weeks for instructional designers to ingest the content into the platform, and then the program director spent approximately two weeks reviewing the content on the platform and providing feedback or corrections back to the instructional designers for revisions. ID estimated that it took her approximately four hours for every one hour of lecture to produce the content in the platform.

FAC-3, who produced her own course in the adaptive platform, said it was very time consuming for the faculty "just getting the content in the state that you want it to be." She had to modify the content so that it would be effective as stand-alone content for delivery inside the adaptive platform. She said creating content equal to an hour of lecture would equate to eight to ten hours of time producing content for the adaptive platform because she had to replicate the content that she would have spoken in class in the platform since "a PowerPoint lecture doesn't have enough information for a student to learn just by looking at just the PowerPoint with bullet points." FAC-2 added that it takes additional time and technical knowledge to put the material into the adaptive platform:

> There's a lot more back-end work than putting together a traditional PowerPoint presentation with the research. There's a lot more programming that goes into it. If you are the one inputting the material into the platform, you actually need to have some type of software background; you can't just have the topic knowledge or that discipline knowledge.

ID said that the first term of the first year contained the largest amount of content on the platform. She said, "In credential one, the actual subtopic nodes . . . are just shy of 300 nodes. . . . That may equate to maybe 50 milestones." ID said that the students would read the content and complete the lesson, then they would complete an assessment of a few questions. Their performance on the assessment questions would be represented as one of five colors for that particular node on a dashboard. The green represents 90–100%, light green represents 80–89%, and so forth until 60% or lower, which results in a dark red circle.

Table 4

Color Indicator of Competancy Level in Adaptive Platform

Score	Color
90–100%	Green
80–89%	Light Green
70–79%	Mustard Yellow
60–69%	Bright Red
Below 60%	Dark Red

The new digital curriculum is easy to assess its currency and update any individual aspect, VIS said.

> Every single topic is like an electronic Lego on a massive electronic wall. You've got 10,000 Legos. If one of these Legos becomes obsolete, it lights up. You can disconnect that one Lego and get rid of it and plug in something new.

VIS said all dental programs have an equivalent amount of content, but other faculty and program administrators do not know exactly what each piece of their content is or where it is

located within the curriculum because it has not been indexed like this program. "Nobody knows what the other person is teaching. They don't know if they're teaching all the right stuff to the competencies or not. They're teaching what they like to teach," he said. He indicated that the new curriculum was easy to update because all content was electronic and organized in small chunks by module-level learning objective making it easy to pinpoint and update selectively with new information.

Implementing the adaptive platform. The initial implementation of the platform in 2017 had a few problems. FAC-2 said, "It was quite frustrating, but we were told beforehand that it would be challenging to bring it up and turn it into a curriculum and we held on to that belief, and it helped us keep our minds straight." He said there was initial resistance from faculty members as well as students. "[The students] did not like the system to begin with. They wanted the traditional way of lecturing and just having that passive material given to them." FAC-1 who taught the first cohort of students on the platform agreed, saying, "We got a fair amount of resistance from the students in the class where we introduced it. And dealing with that was an art in itself."

Gathering feedback. Following the implementation, faculty members and program leaders solicited feedback and refined the content and the way it was presented on the adaptive platform. FAC-1 said,

> We had to say, okay, work with us, and we took their feedback and made changes . . . I deliver a fair amount of material within the very first semester, and one of the things I realized right off is I haven't made my materials as clear as I thought I had. So students were coming back with a lot of questions. And so I started taking notes on their questions and used that in rebuilding my online modules.

FAC-2 said the faculty and program leaders met with the students "almost weekly to monthly, and we took the comments and we slowly changed the system to make it more efficient" and more tuned to their liking. He said that the first cohort of students to use the program gave feedback that program leaders have used to make it much better. At first the feedback was very general, he said, and the faculty members and program leaders had to press the students for more specific details to help make the system better.

Using feedback to make improvements. After running the curriculum in the adaptive platform the first year, the program director and the faculty collected feedback from students, and then the instructional designer, program director, and faculty made major revisions based on student recommendations. DIR said they made three major improvements to the curriculum on the platform. First, they reorganized the content, sequencing, and presentation of the material on the adaptive platform. She said she "made a huge effort this time to painstakingly go through every single bit of content" to include only the content that was needed and put it in the best order for every node. Secondly, DIR said they fixed errors in the content, spelling, and citations and added learning objectives for every node:

> There was one review by the faculty of previous content to find mistakes, to add more information, embellish, improve the information. I go in and look at the organization and restructure. I requested every image have a source. I made sure every node began with a reference section [and] learning objective—which that was not the case the first go around because we were so rushed. Some faculty did it and some did not, but now there's a very strict protocol where I make sure . . . [that every node has a learning objective].

The third major improvement was to redesign how students accessed content on the platform. DIR said they arranged the milestones by timeframe rather than by badge. Each week

was listed in chronological order, and “all the student has to do is find the week they're in and the milestones are presented in the order that they're supposed to learn them. That, to me, was a huge step forward,” she said, adding that those changes were well received by the students.

The second iteration of the pre-clinical program was modified to consist primarily of text organized into meaningful units or nodes with four-to-six randomly drawn assessment questions per node. The nodes were sequenced to build toward the milestones students were to complete each week. In addition, the instructional designers made improvements to their processes and developed a Microsoft Word template with macros that was given to the faculty members for producing content. The template included prompts guiding faculty on what to include on the form. The templates were then returned to the designers and transferred into the platform. ID said the Word templates greatly increased productivity for the faculty and the designers.

This phase of the redesign provided another opportunity to improve content organization. DIR said that revising the curriculum for the flipped design and developing the content in the adaptive platform led to all the content to be redeveloped and reorganized: “It wasn't until we did this new hybrid [flipped] curriculum that they [faculty] had no choice but to revamp everything they did. I really think that it's a huge difference.” She said migrating the content to the adaptive platform led to reviewing, reorganizing, and improving the content, noting, “When you put your content on the platform, you really have to reorganize it and make sure it flows and makes sense, whereas before, when you have a lecture and you're clicking PowerPoint slides, there was no quality assurance.” Placing content in the adaptive platform provided an opportunity for quality assurance. DIR said, “There was a huge quality improvement in the content because now it's being showcased and you have a person like myself going through this content saying, ‘Wait a second, this doesn't read right. This doesn't make sense.’”

Receiving positive responses from students. The second cohort of students responded more positively to the platform than the first cohort. "The second cohort is phenomenal," DIR said. "They're spending a lot of time on the platform and they're . . . more prepared than that first class and more receptive to it, for some reason. They came in the door more receptive to it." She was not certain exactly why the second cohort was more receptive, but she surmised that the content on the platform was better and well organized:

> The first cohort was informed from the very beginning that this was our delivery format, and yet when they arrived, I'd say about a third of them [first cohort] were very resistant and were not happy. From my understanding, we approached the second cohort in a very similar manner [providing an introduction to the platform during orientation]. . . . It's possible that we're doing a better job, too, and that the platform—the content—is cleaner, better organized. That's possible. That might be part of the solution, the answer.

While faculty and program leaders received lots of negative feedback during the first year of the redesigned curriculum, now they were receiving many compliments on how good it was. DIR said, "I heard nothing but compliments about the platform, from the few meetings I sat in on. The students seem really happy and I haven't heard a single complaint." Students can easily find, access, and review content and come to class better prepared. Even on some rare occasions when a faculty member has had to lecture in class, the students have indicated that it was okay because they had reviewed the content on the platform and they were able to keep up with the faculty member, DIR said. The students shared with DIR that they never would have been able to keep up before because so much information was presented in the lecture.

STU-2 was a student in the program in 2017 and experienced the first year of the adaptive platform. She said that the first year was not as effective, but this year has been much

better: “I think at first it was kind of hard [last year] because I don't think they [faculty and course designers] really knew how to make the modules the most effective. . . . But I think it's getting a lot better” because the faculty members and course designers are listening to the students’ concerns and making improvements to the adaptive platform. She said, “In return, I think my classmates are becoming more receptive.”

Teaching and learning in the active, collaborative classroom. In the redesigned curriculum using a flipped model, the adaptive learning platform delivers content and assesses student knowledge attainment outside of class. This redesign made more classroom time available for student-faculty interaction and knowledge application. Program leaders referred to the in-class sessions as content reinforcements. During the content reinforcement sessions, faculty members would choose from a number of different active learning strategies, such as highlighting key concepts contained within modules on the adaptive platform, facilitating discussion, and giving a demonstration of a technique and having students perform the same technique on mannequin patients they each had. Students may work on a case as a group, take a quiz, and participate in other activities.

STU-1 said that active learning is one of the reasons that she chose to attend this institution. She said that when she was applying to the program and came for a visit she talked to then current students and learned the school was using active learning in the classroom. She determined at that point that she wanted to come to this school.

Classroom Observations

Data about the classroom environment and activities were collected during a site visit of two different classes in the fall of 2018. The classes were held in the Simulation Lab designed

for the pre-clinical program that was described earlier. The following sections describe a first-year class and a second-year class, respectively.

First-year classroom observation. A classroom observation of first-year students took place on October 29, 2018. In the three months since starting the program, these students had been working through several milestones on the adaptive platform and had completed one milestone that gave them instructions and a video demonstration of how to prepare a tooth for a filling. They had worked with a system called a Simodont to do a virtual, simulated practice of the task they were to perform that day, but this was the first time they were to pull all of the concepts together, apply them, and practice their skills in a real, tangible environment.

Just before the start of the class, the students, who were all dressed in professional clothes and wore white dental jackets, displayed a high level of energy. They interacted with other students and greeted faculty members. They arranged their stations with their tools. Most students had their laptops set up on the trays at their stations and were reviewing the lesson or their notes. Some used tablets or their phones to call up the lesson, while a few had out notebooks or note paper.

At the start of the class, FAC-1, who was the lead faculty member, greeted the students using the room microphone system. He then established rapport by referencing some of the content and activities the students had been working on and gave some encouraging words about their progress. The faculty member then gave a brief overview of what they would be working on in the class and asked students to pull out their rubrics for the day's activity. A rubric had been distributed at the start of the program to be used for formative feedback and it included columns for self review, peer review, and faculty review. FAC-1 explained how to use the rubic to evaluate their work. They were to compare their work to how the lesson on the adaptive

platform was performed. He added, "If you give yourself perfect at the start there is only one way to go: . . . [laughs] . . . down." The students were to first use the rubric to self-assess their work and skills based on the pre-defined criteria and performance metrics, then they were to have other students review their work and discuss it with them, and then they were to give the rubric to a faculty member to review their work. STU-1 said the students had to rate their own work and then each others' work, noting, "[It] could be a one out of five . . . but . . . they [faculty] won't grade it until you rate it yourself and a peer has graded you." FAC-1, in a side conversation with the researchers during class, mentioned the importance of self-evaluation. He shared that when the students graduate and became practicing dentists, they will need to know how to evaluate their own work and take corrective action to become better dentists.

The lead faculty member gave a demonstration of the process the students were to follow, chunking it into three distinct parts. He demonstrated a procedure on a tooth using the room video system and talking the students through each step. The students were told to review their rubrics and the tasks they were to do, and then to work on their mannequin patients to perform the tasks. The other faculty members walked around the room and checked on the students' progress. Then the lead faculty member walked and talked through the next part of the process and asked the students to do it. The lead faculty member asked, "Can you do your depth cuts in five minutes?" inviting the students to consider their timing and provide input. When a few students responded that they would need more time, the lead faculty member said, "Let's check back in five [minutes]," which asserted his authority in keeping the class on schedule. When some students finished this part of the practice exercise, the depth cuts, they helped other students who were not done. Several students huddled up during various stages of the process to check a certain student's work who seemed to be struggling. STU-1, who was a student of the

first-year class that was observed, said in her interview that she believed there was a benefit to learning in this collaborative environment:

> If someone asks you a question and you're able to answer it, not only does it make you feel a little bit better, but it makes you feel like, *Oh, I get it*. And then if you're not able to explain it properly, it's not necessarily a bad thing; it's like, *Okay, well here's my gap and now I can fill it.* . . . So when you're talking to somebody about it, I feel like you're able to identify where those gaps are right away and then go back and fill them. So I think that's why collaborative learning is the most successful way to do it.

During the class session, one of the faculty members assured his student that she was doing a good job when he said to his small group: "Hey, if you want to see a really well-done example, come over." At the end of the process, students self-reviewed, peer reviewed, and then the faculty member of each group reviewed and rated each student with their rubric. The students were able to review content whenever they wanted, and the faculty members said it was okay to work in groups. This particular class session was focused on skill-building; therefore, faculty members assigned to student groups observed student progress, guided and corrected struggling students, and answered questions as students worked through the material. The lead faculty member asked questions to re-inforce content and procedures and the students called out the answer.

The lead faculty member then demonstrated the next stage of the process. During the demonstration, he and another faculty member discussed two different strategies he could use in this procedure to cut damage out of the tooth without damaging a nearby tooth. STU-1 mentioned in an interview how the faculty members huddle to discuss a particular situation, evaluate a strategy, or bounce ideas off of each other during class. She said, "They make it fun .

. . That's actually a huge thing for me." This particular day, the lead faculty member discussed how he was going to take a less conservative strategy, and then he asked the other faculty member to check his work and assess him with the rubric on the necessary criteria, thereby modeling the formative feedback and self-review process. The faculty colleague gave the lead faculty member a "5" (highest score) for no damage. Another faculty member in the class started clapping and encouraged the class to clap their approval and support, thereby modeling a positive environment and building on the rapport between faculty members and students. The lead faculty member critiqued his own work using the rubric. He asked students to evaluate his work compared to the sample video in the adaptive platform. He said he would rate himself as a 4 out of 5 in this category, justified why he gave that score, and stated what he would have had to do to get the full points, thereby modeling the self-review process.

The faculty members in the room circulated to check student progress. They expressed many positive comments, such as, "You did so well on the last part." The faculty members guided the students on their hand skills, giving them strategies. Then the lead faculty member brought the group together again to demonstrate another technique. After the students had been working, one faculty member gave a gentle reminder to wear their magnifying glasses: "I shouldn't have to remind you," which reinforced good practices. The lead faculty member asked questions to engage the students in anticipating what to do next as he led the demonstration: "Where should your margial . . . ?" The students answered, and he responded that they were correct. Then he demonstrated how that particular procedure would be performed on his mannequin patient.

All students were actively engaged in learning throughout the three-hour class session. They exhibited a high level of autonomy in the class while also interacting with each other, the

faculty members, as well as with the content. The class featured faculty-led instruction in the form of demonstration as well as coaching on the part of the small-group faculty members. Students checked on their own progress, as well as other students' progress in the class. The students provided assistance to other students and exhibited professional and respectful communication. At the same time, the students also had fun. Several students took selfies with their mannequins or posed for photos with other students, thereby demonstrating pride in their work, collegiality, and a sense of accomplishment.

While students were performing tasks, the lead faculty member talked to the researchers and shared some of his perspectives and reflections on the class. He indicated that within the program, faculty members and program leaders placed high value on seeking and making changes based on student feedback. He alluded to a culture of continuous improvement. For example, he changed the way he performed that day's demonstration based on feedback from students and other faculty members. Rather than go through a lecture and demonstration of the entire process, he chunked the demonstration into three parts and had the students do each part directly after he did. He also shared that the content reinforcement sessions were not originally as good as those in the class that was observed. "Our initial content reinforcement sessions were a far cry from what you've seen. They were lacking a year ago." He said he had the opportunity to revise how he conducted the classroom session based on how it went last year.

Additional review and revision came through reflection and discussion during faculty committee meetings. FAC-1 indicated that a curricular integration committee met once per week to ensure consistency across the curriculum and to discuss content reinforcement sessions. FAC-1 as well as the dean indicated one challenge was having consistent expectations of the students and comparable assessment of student work, which they refered to as calibrating the faculty.

FAC-1 and DIR said the faculty had frequent meetings to align faculty expectations of student performance to improve consistency across the faculty.

Second-year classroom observation. An observation of second-year students was conducted on November 1, 2018. The class was also in the pre-clinical curriculum and was held in the same large classroom. Like the first-year class, students were seated in small groups of eight, and a different faculty member worked with each small group. Several students arrived early to set up or practice prior to the start of class. The lead faculty member, FAC-2, took his place at the instructor's station wearing a microphone to lead the day's lesson.

FAC-2 started the class by highlighting the objectives and asking if anyone had questions before beginning. Next, the students all completed a quiz online focused on knowledge retrieval that was accessed with a code. Following the 11-minute quiz, the students received immediate feedback; the lead faculty member went over the correct answers and why the other choices were wrong. The quiz served as a vehicle for class discussion and taking attendance. The students had very low autonomy during the first 30 minutes of class. At the beginning of the review, all but two students were engaged. As the review went on, more students disengaged such that by the end of the review, 12 of the 69 students were off task, talking or using their phones.

Following the review, the lead faculty member gave a five-minute demonstration on the process of measuring. He instructed students to complete the task they were assigned and rate themselves with the rubric, and he then gave them 15 minutes to do so. The students used laptops or tablets as references and worked in clusters. Most finished before the preset time based on the noise level in the room. The longer the task went on, the more students got out their phones and were less engaged in the activity. The lead faculty member asked students how they

scored on the rubric and went over the different criteria. Some students were not engaged in the discussion. Small-group faculty members roamed the room and helped redirect students who were not on task.

This was the first time that the second-year curriculum had been taught using the flipped model with the adaptive platform outside of class and the active learning in the classroom. DIR said the second-year curriculum was being redesigned approximately one month in advance of the material being covered in the program. The faculty members in the second-year curriculum were preparing their in-class sessions just in time for the class session. The lead instructor of the second-year class indicated it took him several weeks to a month to plan one in-class session.

Flipped Curriculum Design Experiences and Perceptions

Moving the entire pre-clinical dentistry curriculum to a flipped design signaled a holistic shift away from teacher-driven lecturing toward student-directed study outside of class and teacher-facilitated, highly collaborative, active learning in the classroom. In interviews, faculty members and students described their experiences with and perceptions of the flipped curriculum model. Each student and faculty member interviewed alluded that the model allowed students to study the material ahead of class at their own pace, come prepared to class to participate in hands-on application of knowledge, and receive highly personalized feedback from the faculty member and other students. Observations confirmed that faculty members used a variety of active learning practices in the classroom and students received frequent and personally meaningful feedback on their work from the faculty members and their peers.

The student experience outside of class consisted of studying the content and testing their knowledge. One student indicated that this type of learning required adjusting her previous study habits. STU-2 described the learning experience in the flipped design with adaptive

learning outside of class and the active and collaborative in class as "very different from my experiences as an undergrad, where you had lecture basically from 8 to 5." DIR described how, each week, students were given four to 10 modules or nodes on the adaptive platform to complete prior to coming to class. DIR estimated that each student would spend approximately 15 to 20 minutes reading a module and then spend additional time responding to the assessment questions at the end of the module. If students missed the questions, they had to return to the content to study more and then take the assessment questions again until they achieved at least 80%.

DIR said the students' schedules were blocked from 5 p.m. until 9 p.m., Monday through Friday, for studying the adaptive content. STU-2 said her learning routine consists of reading the content on the platform, taking notes, and then answering the assessment questions at the end of the modules prior to going to class. STU-1 described how she would go over the content in adaptive platform before class and then ask questions to address her uncertainties in the classroom. Faculty indicated classroom sessions are scheduled during the day for three to four hours. STU-2 said her classroom sessions consisted mainly of a content reinforcement portion in which the faculty member highlighted the main points that the students were to glean from the content, and then the students would apply what they were learning through a variety of active learning methods.

Self-Study, Application, and Feedback

The flipped design enabled students to study content and to be assessed on their understanding outside of class, and then come to class to apply what they had learned. Faculty members and students interviewed indicated that studying the content then applying their

knowledge in class and getting feedback from other students and faculty helped them learn better and retain what they were learning.

STU-1 indicated that the flipped model allowed for a combination of three ways of learning—reviewing the content on the adaptive platform and taking assessments, applying the information in a practical setting through active learning strategies like demonstrations and hands-on practice, and then receiving personalized feedback from the faculty member:

> I think all three of those parts put together are best if you read it first, get a demonstration, and then do it yourself. That part of the active learning is probably the best way, because I've read it and I've seen it once before. And not only that, but when the faculty showed it to us, they gave us a little bit of their personal experiences and their personal tips and so we're able to apply it.

All of the faculty members teaching in the pre-clinical program had previously been in private practice. They used that experience to guide the students in gaining knowledge and skills they would need in becoming dentists.

STU-1 said that the mix of adaptive learning and active classroom learning works well for her. She said her first experience with learning in the adaptive system "was a positive thing for sure." She added that the flipped model that combines the adaptive platform outside of class with the in-class content reinforcement session fits her preferred learning style. "I think having a flipped classroom where you don't have some type of content reinforcement, that's where it could be negative. But if you have a content reinforcement on top of it, it's actually a really positive thing." STU-1 said she benefitted by being able to review the material, test her understanding, and then have time to process the information and formulate any remaining questions that she could ask in class:

> I personally believe that if you look at it [content] once, it takes time before a question can be formed because, for me, I need to look at it a few times before I even know what my questions are, where my gaps are that need to be filled.

STU-1 described the design of this program as "very interactive; it is efficient, and I think everyone is willing to help, whether it's a classmate or colleague or a faculty member, which the faculty members treat us as colleagues, so that's huge."

STU-2 said that she has been very satisfied with what she has been able to learn in the program so far:

> I think at first, because we're given so much material, that I got kind of concerned that I wasn't learning enough. But then we go to actually apply it, I do know what I need to know to be successful, and so that's been kind of nice to reaffirm that it's working. . . . We go to clinic and we see our patients and we do exams for the upperclassmen, and I'm scared that I'm not going to remember something that is really important. But in that situation, it just was coming to me, and I was able to do it successfully, and so I realized that it's working because I'm remembering it whenever I need to remember it, if that makes sense. So it's really helpful. . . . At first we're given so much information in dental school, and I'm sure any professional or any kind of school, but we're given so much that you're like, oh, I'm going to forget something, or it's something really important. But the important things I have been able to retain, which is great.

STU-2 expressed that the design of this program was helping her not only apply her knowledge immediately but also remember what she had learned. She described how she easily remembered things she learned last year as she was performing skills and applying knowledge in her clinical sessions this year.

STU-2 said that the combination of adaptive content and in-class content reinforcement in the flipped design is benefitting her: “I'm able to focus my time better on certain topics. . . . I'm able to go back and understand the module even better a second time because I've had that content reinforcement.” She said that the flipped design of the curriculum was helping her understand and apply what she was learning in the program:

> I'm reading the module, and then right afterwards, we're applying it to our sim [simulation] sessions. . . . Especially with the videos and everything that they're incorporating [into the adaptive learning modules], it's a lot easier to come in to class and feel prepared to contribute and work versus coming in not knowing anything. So, I'm able to take what I'm learning off of [the adaptive learning modules] and really apply it right away, which is great.

VIZ highlighted three aspects he believed were most impactful about the redesigned curriculum. First, students’ personal learning needs were being met through the ability of the adaptive system to measure the knowledge gaps and provide content. Secondly, students are immersed in actively applying the content, critically thinking, solving problems, and using their new knowledge. Lastly, students’ soft skills have been developed through formative feedback such as rubrics and self-evaluation. He said that all of these things were improving learning:

> To me that's an important thing, the knowledge gaps and then—active learning is making the students responsible for their education. You learn it by being immersed and engaged, and you learn it through critical thinking and problem solving. You raise long-term retention rates up to the 80% level. That's in the research. Then, learning the soft skills, the formative skills. Those are the key points of results.

Interaction

The flipped model opens up class time so that faculty members can interact with their students on a personal level. Rather than lecturing, faculty members facilitated students actively processing what they were learning by having them apply new concepts; the faculty members would walk around the class to observe and give personalized feedback to students on an individual level.

FAC-3 said that flipping the classroom allowed students and faculty to have time in class for conversations about patient cases and treatment plans and to discuss what the students were actually learning:

> I have developed more cases and we have a more interactive environment now than before where it was just me standing up there lecturing where I didn't have time to really go over real patient cases. . . . I have conversations and discussions about it [the content] so they could understand what their real learning was from the information.

She has found that she now has more time with the students and can work with them one on one or in small groups to apply the information. "In the past [I] would've had maybe an hour of time with them and now I have hours over the semester where I can actually work with them . . . to go over the content and the application of the information." The students told FAC-3 that they liked the classroom setting because it allowed them to discuss the content in class and to fill in gaps where they didn't understand. FAC-1 said that flipping the curriculum has given him "more face-to-face time with the students, and not just working on the hand skills—which is significant—but also a series of one-on-one meetings throughout the semester where we review their progress."

Teaching

The increased interaction between faculty and students in the classroom has led to a more rewarding teaching experience for the faculty. FAC-2 indicated the new flipped design has been more rewarding for him as a teacher, and he believed the students were learning more:

> I see my group of students grow faster and more intimately than I did before. It does take more of my time to work with those students, but I think to see the students progress at a granular level, to see them critically think, that is well worth the additional time that needs to be invested in the students.

FAC-2 continued, "Working with the students one on one, I see the students asking more questions in small groups than they ever did in a single large session where they may feel publicly humiliated for asking a certain question." He said this design of the program requires students to "critically think, which was the biggest part that was missing from the old curriculum and even if the students were to get the answers wrong, at least they're trying, they're actively trying to come up with the answer." He thought the students were actually learning more now. "Yes . . . They may not think so, but I think subconsciously they know more than what they expect."

Self-Directed Learning

Self-directed learning is dependent on the students taking the time and effort to read and study the material outside of class and asking questions if they do not understand. Even though the students' schedules were reserved from 5 p.m. until 9 p.m. every day for studying the adaptive content, DIR said not all students took the time to read and understand the content on the adaptive platform on their own. STU-2 said it was a big adjustment for her to get used to the flipped curriculum model and the amount of time required for the program. She said she had to prioritize intentionally her time outside of class. STU-2 said that some students would not read

the content and would instead jump directly to the assessments. This was particularly a problem the first year of the redesign because modules contained only about three assessment questions each. STU-2 said students would try to answer the quiz questions without reading the material because they knew that if they did not get the questions right the first time, they would get the same questions the next time and eventually guess the correct answer. She gave this feedback to program leaders. DIR described how it was a goal to have several assessment questions but that developing the questions was time consuming. However, after completing the initial redesign and offering the program in the adaptive platform that first year, she and the other faculty members went back over the summer and devoted time to creating more assessment questions. The second year the program was offered, the number of assessment questions were increased to four to 10 questions per node and the system randomly pulled three or four of those questions to present to students.

FAC-2 voiced concerns that the students may not fully understand the material while going through it on their own. "From a student standpoint, I think they're going over the material, but I'm not sure if they know what they don't know." He was concerned that students may not realize when they do not understand something and they may be studying the information with misconceptions. STU-2 and STU-1, on the other hand, indicated they liked being able to go over the material before class so that they could ask questions either in class or by sending an email to their professors for clarity.

Time

Faculty members indicated that they needed to invest many hours redesigning their classes. FAC-1 explained how it took many hours to redesign the curriculum in preparing the content for the adaptive platform and then in planning and preparing his classes in the active

learning style. He added, “The next challenge was just learning how to present the content reinforcement, what was important to reinforce, and then staying focused.” FAC-2 said it took a lot of reorganizing and planning. “You really can't put a session or a course together within . . . a week or so. It takes a good month or so to assemble everything so it runs relatively smoothly,” he said. FAC-3, who was the second person to put her course in the adaptive platform, described how she spent a considerable amount of time redesigning the content. “I've really had to look at what is important, what's not important, and am I giving that information in the way that they can understand and digest and use it.” She added that she believed that redesigning the course made it much better and the process had been really valuable to her as an educator.

Student and Faculty Resistance

Both faculty members and students interviewed indicated they were aware of resistance to the redesigned curriculum. FAC-2 said he saw resistance in some of the faculty members and students. He said they did not want to change from the traditional lecture-based way of teaching. He said, “I was taken aback by how much resistance there was from the students and . . . from the non pre-clinical faculty.” He said he heard comments like, “We know it [the old way of teaching] works, so we should just continue to do it the way that we've been taught for the last thousand years.” FAC-2 said “[The students] did not like the system to begin with. They wanted the traditional way of lecturing and just having that passive material given to them.” FAC-1, who taught the first cohort of students on the platform, agreed, saying, “We got a fair amount of resistance from the students in the class where we introduced it.” VIS agreed that resistance to change was a challenge. “I would say the challenges or barriers are, first of all, attitude of the administration and attitude of the faculty.”

Adaptive Learning Experiences and Perceptions

Faculty, program leaders, and students indicated in interviews that redesigning the curriculum to use the adaptive learning platform introduced a number of advantages over the previous methods of delivering content. They indicated personalized learning path, self-paced learning, frequent assessment, and analytics as benefits afforded them through the adaptive learning system. The following sections convey the data collected relative to each of these expressed aspects of the adaptive learning system.

Personalized Learning

One advantage of the adaptive platform is the ability of the system to create a personalized learning path calibrated to the knowledge level of each student. Assessments given to students at the beginning of the program measure learning gaps and enable the system to place students on learning paths targeted to their individual needs. VIS said that some students are admitted into the program with prior study in the discipline. For example, one student may have a master's degree in anatomy, while others in the cohort of 69 students may have no prior coursework in anatomy. "They're all graduate students coming into dental school [yet they have very different learning needs]. How do you deal with that?" He said the traditional way of educating them has "always been one size fits all. We throw them in a big classroom" and start lecturing the same content to all of them. He said that the student who "comes in that doesn't know any anatomy has a huge knowledge gap compared to the one that has a master's degree." Now, with the adaptive platform, VIS said that the student who has a very low knowledge proficiency may have to spend more time studying the content in the platform, but he or she can catch up to the student who has a high knowledge proficiency. "I've seen this in our data. . . . I've seen some kids spend 20, 30 hours, and other kids spend two hours but their knowledge

proficiency is the same [by the end of the course].” VIS described how the adaptive and flipped learning environment can give every student the opportunity to excel based on the time and effort they expend to learning the content:

> It takes away that measure of success and failure of how much time did you spend. At the end of the day, they're both equal in knowledge proficiency. The kid who is slower or less knowledgeable doesn't develop that attitude that . . . he or she is better than me. Instead, they feel proud of what they've learned. They feel adequate and accepted. So, that's really, really powerful with an adaptive learning, flipped classroom environment because it embraces every single personality in that room and every single level of knowledge they come in with.

Self-Paced Learning

The adaptive platform allows students to study the material at their own pace prior to class and has opened class time for more interaction. It provides frequent assessments and feedback along with a personalized dashboard summarizing each student’s knowledge state. STU-2 described how she likes being able to focus more of her time on what she needs to learn:

> I was able to spend more time on the things that I didn't understand and less time on the things that I did understand. So it could have helped me really be able to go through and read the stuff that I didn't get as well and then ask questions. I just email professors and just ask them questions, and they're really good about emailing me back.

FAC-3 said her students told her in course evaluations that they liked the ability to go through the material at their own pace and preferred adaptive learning over lecture classes. She said she encourages the students to use the platform and go through the assessments more than once to continue to test themselves and their understanding of the content. VIS said this makes

students responsible and accountable for their own learning, which can also be problematic, as mentioned in the section on the challenges of self-directed learning.

Assessment and Feedback

The adaptive system utilizes frequent assessments with immediate feedback to the students. VIS and DIR explained how the previous curriculum model of lecture and test provided an infrequent snapshot of student learning. DIR said they used to give only three to four exams per term. They were long tests over many topics occurring at long intervals. VIS said that if students were struggling with understanding some concepts, it would not be discovered for possibly several weeks, at which time it would be difficult to go back and correct misconceptions and gaps in understanding. Now, DIR said, students are being assessed all the time. They complete several assessment questions per week and the system immediately identifies knowledge gaps and redirects the student back to the content that they need to study. VIS described the assessment capabilities of the adaptive system:

> As you progress through, if you studied some nodes four weeks ago . . . and I'm assessing you on information that is coming from 15 different nodes, and you start getting question three wrong that happens to be attached to node three, that changes that node color. You go from green to orange. Well, you can't get out of this class till you get everything green. . . . It's [more challenging] because you have to assemble this knowledge and answer more and more complex questions, multifactorial questions. If you start getting those wrong, the platform is identifying where that information is coming from that you're getting wrong, and it's turning that node a different color. Now, you have to go back, and you have to review that node before you can come back into the node you're

> working on so that you can attempt those gaming questions again. It's really a gaming environment through and through.

ID also described the assessment and scoring components of the adaptive system. She said students take biweekly quizzes in class that reinforce their knowledge attainment. If they do not perform well on the biweekly quizzes, their scores for the nodes that covered that content go down:

> As an instructor, I can go look at a student and look at their questions and I can see how something's effecting it [their grade]. So, they had a 99% in this node before they took the [biweekly] quiz. Well, they did poorly on the questions coming from that [node]. It dropped them down to a 75%. So I can look at each student like that and see, okay, well where are they struggling. Some of the students they'll be at a 99 because they just went in and took some questions and left and never really looked at all of the questions that were in there. It will drop them down, so that 75%. She's going to have to go back and go through that node again and either look at some more content or at least take the questions again. One of the requirements by the end of the course is all of their nodes have to be at a certain percentage.

Students are required to have 90% on their questions in the adaptive platform in order to take the course exams, DIR said. There are three exams in the first term for the first-year students, including a midterm and a final, according to ID and DIR.

STU-2 found that the immediate feedback and encouragement on the adaptive platform helped her to learn the material and motivate her to continue:

> Every time you answer a question, it's like “well done” or if we don't [answer correctly], it gives an explanation of why it wasn't right. And so that's also helpful because then I'm

> able to see why I made the mistake I did on the question. So it's more interactive, obviously. So it's more motivating, I guess.

Analytics

The adaptive learning system stores analytical data on student use of the system and student performance on assessment questions. It provides the faculty members and program leaders with detailed analytics to see better where each student is excelling and struggling and to analyze the effectiveness of assessment questions. Program leaders and faculty are able to use the adaptive learning platform analytics to monitor student progress, activity, and problem areas. VIS said,

> Of course, every faculty had access to the powerful analytics, and so they could monitor every single student in real time 24/7. What are you reading? What are you not reading? What questions are you answering wrong? How many times are you answering them wrong? What answers are you giving wrong? How much time are you spending on each question?

ID said that, although they have not had much time to explore the assessment data, they use the analytics to see at a high level how students are performing and who is completing what content. Each instructor can see his or her class and see which students are ahead, which are right where they should be, and which ones are lagging behind.

The adaptive platform provides assessment data indicating what students are understanding or not understanding. With that information, the faculty member is able to revise content in the platform or take time during content reinforcement sessions to go over something in a different way. VIS said that the analytics are very powerful and give real insights into the learning and activity of each student:

> It's just amazing what you can do with it. Because it's a powerful AI [artificial intelligence] engine. It's big data. There's no limit to the what you can monitor. You create your own dashboards, and you can monitor students that way. . . . I'll know tonight if you're my student, and you have a lesson plan for tomorrow; I can watch you from my couch on how you're progressing and what you're understanding and what you're not understanding about tomorrow's session.

VIS said a significant advantage of adaptive learing is the information the faculty can get immediately from the system about how each student is performing. The combination of frequent assessment questions, immediate grading, and system analytical data that measures both system use and student performance provides instructors with a detailed picture of how each student is doing at any moment in the course. If a student is struggling with assessment questions in the first or second week of class, the faculty member will know and can intervene to help the student. If a student is not engaging with the content on the system, the instructor will know that as well. Faculty members do not have to wait until the first exam is graded to see that a student is not understanding the material or is not engaging with the course content.

Learning Effectiveness and Satisfaction

The need to rethink, reorganize, and redevelop the curriculum content for the adaptive platform provided the opportunity for the program leaders, faculty, and instructional designers to improve the curriculum. DIR and ID indicated that they and the faculty aligned content to learning objectives and organized it meaningfully by credential, badge, milestone, and node to help students scaffold their learning to achieve the knowledge and skills they needed to be successful in the program. DIR said they fixed errors, spelling, and citations and added learning objectives for every node. She said the faculty reviewed content to fix mistakes and add any

needed content, and then she reviewed the content and "look[ed] at the organization and restructure[ed it where needed]. I requested every image have a source. I made sure every node began with a reference section [and] learning objective."

FAC-3 said she redesigned the organization of her course material on the platform to make it more user-friendly and, in doing so, received positive feedback from students through course evaluations. She added that her students told her that they believed they were learning more from having the content in a different format than lecture. She said that they were performing well in the system, but to ensure that they were actually understanding the material, she would also deliver a written exam in class:

> I've taken questions that were delivered as part of each topic from the platform and put it in the exams or quizzes, too, because I want to see if they . . . [are] actually still retaining the information. I would say, consistently, they are.

STU-2 said that learning with this curriculum design and reviewing content on the adaptive platform has been a benefit to her. She believed she was learning more than she had been able to learn in a traditional lecture-based program, and she was more motivated to study the material and answer the questions because she could see her performance improving:

> I've definitely been able to retain more, and I think part of it is just looking at my grades from a lecture-based class to the adaptive class. I mean, I do okay in the lecture classes, but I do really well in the adaptive classes, and I think that's just because I do take the time to read through it [the content on the adaptive platform], and I review it after the content reinforcements, and it [the platform] kind of motivates me to do it on my own. So I think I'm just able to retain it better because I look at it more . . . I'm clicking through it, and I'm answering questions, and it's telling me, "You're doing well" or "You got this

> question right." And so it's more motivational for me to continue to keep looking at it and see my progress versus let me just read this PowerPoint over and over again and try to retain it.

Active and Collaborative Classroom Learning Experiences and Perceptions

Class sessions are designed as a time for the students to apply what they have learned, to articulate what they are learning, to evaluate their own and their peers' progress, to have their progress assessed by the faculty, and to receive personalized feedback and coaching on their knowledge attainment and skill development.

Creating active and collaborative class sessions requires planning and strategies. The program director indicated that the objective of the in-class learning activities was to reinforce the learning goals and give students practice. DIR said,

> When they plan the activity that applies to the foundational content, the idea is that activity would bring home the learning goals via the student doing something. The activity could also serve as an assessment tool, meaning the student applies the knowledge correctly. You could use challenging questions like prepared talking points, . . . patient cases, to answer a question, to apply the knowledge presented . . . so there are many approaches.

DIR said that, early on, she and the faculty created a standardized agenda template that is shared with the students in advance of each class. She and the faculty also held several retreats during which time they brainstormed a list of active learning practices for their content reinforcement sessions. They developed a list of four main areas or goals for the in-class sessions:

> One is to definitely start by describing the relevance of the session, of the lecture topic, to patient care. Number two is assess student understanding coming in—give them a low-stakes quiz. Number three is plan an activity that applies to the foundational content. The fourth goal is to summarize the key points and clarify areas of confusion, so it's very important at the very end to do a wrap-up.

These practices were seen demonstrated in the first- and second-year classroom observations, described earlier.

Assessment

The active and collaborative classroom provides opportunities for a variety of assessment techniques for having students demonstrate their understanding in several ways. During classroom observations, faculty members of the first- and second-year classes used several different assessment methods. The first-year class performed specific dental procedures then evaluated their own work and evaluated another student's work. The second-year class took a quiz and performed a dental procedure.

During an interview, FAC-3 described how she uses multiple assessment strategies during each four-hour class session to ensure that students are truly learning the material; she said students come into class, take a quiz using TopHat polling software, and then complete the same quiz as a team using scratch-offs that are pre-keyed with the correct answer. The students work as a group to come up with the correct answer. If they do not get it the first time, they keep answering until they get the correct answer. "I have them do that as a group to share their knowledge on that question and to understand what the right answer is to make sure that they are going over the quiz together as a team." This strategy incorporates collaborative learning as well. Then FAC-3 has her students work in groups on eight case studies in each class session:

> Once they do their quiz, we do our content reinforcement. Then they break out in their groups. . . . They work through the cases, answer questions, submit the responses into ExamSoft. Then . . . each group has to come up and present one of the cases to the rest of the class and showing what they answered. Then I'll backfill when they're done giving their answers with how I would've answered it or agree with them or elucidate more from how I would've answered the question.

The cases help students apply and synthesize all that they have been learning in their lessons.

Student Participation

Active learning in the classroom necessitates students actively participate in their own learning, which is not always well-received by the students, as mentioned earlier in the section on student and faculty resistance. FAC-1 indicated that the students were not used to taking ownership of their learning, saying, "It was a tough transition for them to have to be . . . the masters of their own learning." He added the students do not realize how much the faculty members have done to structure the learning materials and activities to create meaningful learning opportunities. He said it was difficult "helping them to realize that they're not teaching themselves."

All the faculty members interviewed indicated that the students would sometimes complain, "Why don't you teach us?" FAC-3 said students have told her how much they like it when she lectures. However, she said they have a much different perception of what it means to lecture, as compared to what the faculty member sees as lecturing. She said that her current students are only familiar with her content reinforcement sessions in which she presents a brief, "top ten take-aways" from the content students were to have studied on the adaptive platform. She said her students consider that lecturing, but they are not familiar with her actual lectures in

which she would present content for an entire four-hour class. "When I had it the other way [and lectured for four hours], they hated it. They would be all, 'Lectures get boring. It's too much information. I wish we had more time to be able to do.'"

FAC-3 said she can see that her role as a faculty member has changed with this new model of teaching, but also the role of the student has changed. She said, "I think I'm more facilitating their learning in partnership as opposed to me just standing up there and telling them something. I think that's probably what's different . . . in partnership with them. They have to take ownership of some of it."

Rapport

Active classroom sessions allowed for faculty members and students to build relationships and rapport. During classroom observations, faculty members demonstrated an interest in students when they got to know students personally, shared personal stories, and coached students on their techniques. As described in the classroom observation section, faculty members interacted with their small groups in the classroom, observing their work, providing encouraging words, and suggesting strategies to try. Students also helped each other. Students who finished early checked on other students and provided assistance. Faculty and students would also joke and have fun in class. As one example, a first-year faculty member teased a student about his choice of baseball teams. A World Series game had just been played the night before, and a student had placed a rival team's baseball cap on his mannequin. Students posed for pictures with their mannequins and in small groups demonstrating their collegiality, pride in their work, and sense of accomplishment.

Formative Feedback

This program infused another key element into the active classroom—formative feedback that was specific to the performance and interests of each student. During classroom observations, students used rubrics to assess their own work based on the criteria outlined in the rubric; then they reviewed other students' work utilizing the rubric. After giving and receiving self and peer feedback, they were to seek review by a faculty member. VIS, FAC-1, and the dean all indicated this immediate, specific feedback on student performance was a key element that helped shape and guide student development and growth as professionals.

The requirements of the rubric review process dictate self-review, peer-review, and faculty review using the rubrics. STU-1 said,

> In our rubrics, we have to grade ourselves, we have to have a peer grade it, and then faculty will grade it. . . . That's huge on collaborative. . . . It's like, get all these opinions before you come to us and then they will refine.

Students also received formative feedback through individual coaching by the faculty. STU-1 said that the faculty members have provided very individualized help and instruction:

> They're always floating around, and because they check your work one on one, they tailor it to the individual, which I think is super helpful instead of just as a class saying, "Hey, make sure you do it like this." Even like posture or like how I'm holding my drill, they'll stop and be like, "Hey, I noticed you did this; try it like this." And they're so positive about it.

FAC-3 indicated that this curriculum design allowed her to focus on the needs of individual students in her teaching. She uses data from the adaptive platform, exam scores, and in-class interactions to provide very personalized coaching to each student:

> I think my ability to see that [in-class interactions], plus then when I meet with students who are struggling, I can say, "Okay, it seems like you're struggling with these types of things within each area," and help them refocus, especially in a struggling student who's not getting it. I think I can tailor what I need them to do next by both the platform and then obviously, their examination results. I can say, "You need to go back and study this material because I'm seeing that, number one, you're not going into that material enough," and also, "On your exam, this is what seems to be the issue," based on what questions they get wrong and stuff like that.

STU-1 said that the faculty members also share personal experiences that add to the learning experience. The faculty members collaborate with each other and huddle to discuss a particular situation, evaluation, or strategy and will bounce ideas off of each other during class. She said, "They add a lot of personal; they make it fun; I don't dread it at all and . . . that's actually a huge thing for me." FAC-2 said that in class, the faculty "put our own personal touches . . . onto the sessions. During our small groups, we provide our tips in private practice . . . [and] insight on how the students should be thinking."

One of the challenges of using formative feedback was calibrating the faculty to all have consistent assessment criteria and performance expectations in evaluating the students. FAC-1 said, "We've got to make sure that the faculty is on the same page with the basics and make sure we're assessing things equally, or at least similarly." DIR said that in the prior semester the discipline expert held weekly meetings for the core faculty members to help calibrate and add consistency to faculty assessment of student performance.

Collaboration

Student interviews and classroom observations noted benefits received from students collaborating with each other in the classroom. STU-2 said she found it beneficial to be able to collaborate and learn from others in small groups and she specifically mentioned how it was useful to hear how the other groups had responded to their cases:

> It's really helpful to see all the different points of view because in dentistry not one thing is always right. There can be multiple plans that are right, and so it's interesting to see what other people think is the right plan, and then maybe that can make me change the way I think for the next time.

STU-1 also said that collaborative learning has helped her:

> Collaborative work in Sim [Simulation Lab] and in support lab and outside of that, what we're doing—our own study groups—that's been huge for me. That's probably why I've been doing well so far just because we have each other to help out.

Observations of classroom activity noted students supporting each other and teaching each other how to perform procedures following class demonstrations.

Dialogue

Students interviewed indicated they benefitted by having the opportunity to express their understanding and discuss with other students how they understood concepts from the content they were studying. STU-1 said it helped her to be able to work together with other students saying, “Okay, if I don't have it, maybe my partner has it, and if she doesn't have it, then we'll figure it out together.” She also described how articulating her understanding to another student helped her truly understand what she knew and did not know. “Well, for myself, reading something gets me to the basis of it, but talking it out is what really pushes me over the edge

where I'm like, okay, now if I can explain it to you, then I get it." She also believed there was a benefit to this learning environment that encouraged dialogue with others:

> Being in an environment where there are other people usually primes you to ask questions and then answer questions that your classmates are going to ask you. . . . It's good, I think, teaching other people concepts really reinforces whether you know it yourself or not.

While getting used to sharing ideas with others in class has been an adjustment for STU-2, she said she has been able to develop many skills through working with other students in class:

> I think it took me a little while to get used to it [sharing ideas] . . . But I think it's helped me become a more outgoing person and made me think more critically because questions are posed to me that I have to come up with an answer to, so I think it's made me grow a lot as just a person because I'm able to talk with other people more than just a lecture.

STU-2 indicated she thought she learned better by collaborating with others: "I feel like it makes me learn better because . . . maybe they got something out of the module or something that I didn't understand or I didn't think of, so then I'm able to apply it." She said it is also helping her develop her communication skills.

Faculty Perferences

The faculty members interviewed indicated that they enjoy teaching in the active collaborative classrooms. They said it was more fun, rewarding for them personally, and more engaging, and it seemed like it was more impactful for the students. FAC-2 said, "From an individual faculty standpoint, it was a lot more collegial, a lot more fun, a lot more engaging. I felt like I have had more—a grander—impact on a student's life or educational career. It felt more rewarding." FAC-1 described his in-class experiences as varying "from the formal

instructing and giving feedback to developing relationships with the students." FAC-3 said the active and collaborative classroom gives her a chance to interact with students, and it gives her a better understanding of what each student actually knows:

> I like that I get to interact with them in a different level, like more one on one or at least in their groups. I get to really see their knowledge as opposed to me just standing up there talking—I don't know what's sticking and what's not. [Now] I can see it when I interact with them in class, plus I can see that they've actually gone through material before they even come to class. [Before] I wouldn't know that if I'm just assigning them a reading or something of that sort. I wouldn't know if they've even gotten into the material.

FAC-1 shared that he thought the increased interaction with the faculty is a benefit in the new curriculum model:

> But I think a big part of it is just the increased interaction . . . direct interaction with the students which give us more of the informal teaching moments. And so, we can go far beyond what's in the online curriculum, and learning the hand skills, and we can talk about applications. There's time to tell some of my war stories from practice [and] give advice as they prepare.

Preliminary Outcomes

Since the pre-clinical program redesign has not been completed and the second year of the curriculum is still being developed, outcomes data are not complete or conclusive. There are, however, early positive indications from the changes made to the curriculum and the delivery methods. For example, one faculty member believed that the students seemed to perform at equal or better levels than students in traditional lecture on national exams. FAC-3 said,

> Students . . . take an OSCE [Objective Structured Clinical Exam] in their third year, and in their third year, it's similar kinds of cases that they have to also answer on an exam that they were doing in this course. . . . I started to look at that and then also the National Boards Course II to see how we're performing. I think from what I've observed, they're performing at or above what others have with the traditional lecture-based. . . . It's definitely to me what I'm observing is that they've improved. . . . It will be interesting to see if that's a positive correlation, like that's enabled more success on some of these kinds of high-stakes exams.

She indicated that they still need to look at the test scores, but it is her goal to start to look at the outcomes data.

The first semester the redesigned curriculum was offered, DIR collected data and analyzed the findings. "We looked at the various disciplines, and we were able to show by looking at tagged questions in our written exam that students did better in many areas. They actually did better than the previous cohort." Other indications of success were anecdotal. DIR shared,

> I'll tell you, and even today one of our faculty was saying, boy, the students are more engaged than he's ever seen before in the content reinforcement session and when the faculty is asking questions they actually can answer, whereas before they weren't. . . . He's very impressed with their level of knowledge and this is the first cohort.

VIS indicated that students are finishing their course material in less time and doing two to four times as many procedures as they were doing in the old curriculum design:

> What we found just in the first year is that, almost to a T, the entire class finished the whole first-year program in half the time and came to us begging for more. What we're

> seeing after two years of this is that we think students are going to finish in a third of the time. And they're doing twice as much work. Some of them are doing three and four times the amount of required procedures than were in the old traditional environments.

FAC-3 observed that there were fewer course failures following the curriculum redesign as compared to previous cohorts:

> I've been looking at their performance over the course of time compared to other cohorts, and they perform at or above what others did . . . I would say there's less course failures. At least that's my observation.

Another observation pertains to how the students perform once they arrive in a clinical environment. FAC-3 indicated that students have been able to apply what they were learning and were able to write up patient cases and treatment plans better than prior cohorts of students.

> This is all anecdotal, but in the clinic where they're seeing patients, the faculty tell me that they're better at writing up what they're seeing. . . . They are actually better than other cohorts were in the past at doing that because that's what we're really getting them to do, see something, write it up to say what it is and then what do I do next. . . . So that it's translating to better clinical care from what I've observed from or heard from faculty who oversee them in clinic. . . . Better application of that knowledge because they'd have to understand it to be able to write it properly. They have to know this is what's normal and this is what's abnormal, right, then they can actually describe what they're seeing as the abnormality that they clinically have identified.

Summary

Chapter 4 presented qualitative data from the case study. Summaries of the in-person, semi-structured interviews; site observations; classroom observations; and examination of

documents and artifacts related to the redesign of the program were presented through themes identified in the data. The logic flow of Chapter 4 included examination of the curriculum design and process of redesigning it, followed by faculty and student perceptions of and experiences with the flipped model; adaptive learning; and active, collaborative learning. Faculty and student experiences with and perceptions of the flipped model was a theme that explored how the model enabled the adaptive and active elements of the design but also introduced benefits and challenges. Findings related to adaptive learning explored personalized learning, students' ability to learn at their own pace, advantages of frequent assessments, power of analytics, and the redesign of content for the adaptive platform. Themes pertaining to active and collaborative learning identified many elements that impacted teaching and learning, including multiple ways of assessing, student ownership of their learning, relationships and rapport in the classroom, personally meaningful formative feedback, aspects related to collaborating with other students, the advantages of dialoging with others, and faculty perceptions of increased collegiality and connectivity with students. Lastly, preliminary and anecdotal outcomes were described. Many aspects can impact teaching and learning experiences and perceptions; therefore, several topics were explored as themes. Key themes noted were determined by frequency and significance as indicated by faculty members and students or observed in the case study program.

CHAPTER 5

SUMMARY, DISCUSSION, IMPLICATIONS, CONCLUSIONS

The purpose of this case study was to explore the curriculum design as well as faculty and student experiences in a graduate program using a flipped course design model that incorporated an adaptive learning system coupled with active and collaborative classroom learning. Through qualitative analysis, this study examined the design, the experiences and perceptions of students and faculty members, as well as the outcomes of this program.

This chapter will summarize and discuss the findings of the study. Then, the chapter will cover the conclusions and implications of the research, suggest areas for further study, and end with a summary of the study.

Research Questions

This study focused on a curriculum designed in a flipped model which incorporated adaptive learning outside of class and active and collaborative learning in the classroom. The case study examined the following research questions:

1. Why and how was the design of the curriculum of a graduate medical program in the Western United States changed?
2. Have, and, if so, how have student outcomes in the graduate medical program in the Western United States changed following the curriculum redesign?

3. How do students and teachers describe their perceptions of and experiences with adaptive learning in the graduate medical program in the Western United States?
4. How do students and teachers describe their perceptions of and experiences with active learning and collaborative learning in the graduate medical program in the Western United States?

Summary of Findings

Interviews with subjects were semi-structured to facilitate the exploration of the research questions while allowing the freedom to delve deeper into emerging topics. The themes and supporting data provide a condensed yet detailed report of classroom and site observations as well as interviews conducted with students, faculty, program leaders, and instructional design staff. The findings are organized under four major categories: the redesign of the curriculum, the flipped curriculum design, the adaptive learning experiences and perceptions, and active and collaborative classroom learning experiences and perceptions. The following provides a detailed synopsis of the findings of this study.

Curriculum Redesign

The first major category relates to the redesign of the curriculum and the design process that was undertaken. Interviews raised common themes related to the redesign of the curriculum. Program leaders and one faculty member described the old curriculum design as siloed, centered on memorization of facts, and disconnected from students' aspirations of becoming dentists. Redesigning the curriculum was an opportunity to modernize it, make it agile, and incorporate more hands-on application and critical thinking. Themes pertaining to the redesign of the curriculum which are summarized below included mapping and integrating the curriculum,

flipping the curriculum, incorporating adaptive learning, using feedback and its effects, benefitting from the redesign, and using active, collaborative learning.

Mapping and integrating the curriculum. Program leaders and designers spoke to the detailed work of mapping and integrating all of the content across the pre-clinical curriculum. The process involved identifying all content being taught in the program and aligning and organizing the content in a way that supported the learning objectives of the program. They described creating a large curriculum map that included each topic in the program. Program leaders and designers all mentioned how the process of mapping the curriculum helped to identify gaps and eliminate redundancy in the content. The new curriculum was reorganized around patient care and was integrated across the different disciplines within dentistry. This structure gave students access to clinical work several months to over a year earlier than the prior curriculum design. The earlier entry into clinicals afforded students the opportunity to apply what they were learning in the field of dentistry sooner and more frequently than they had been able to in the past.

Flipping the curriculum. Program leaders spoke of the flipped model as being a necessary component in achieving their goals for the program redesign. Following mapping and integrating the curriculum, VIS described the next stage of the redesign, which was flipping the classroom. His development and offering of a pilot course in the flipped model served as a proof of concept before expanding the model to the other courses in the program. With his students' scores increasing by 15% in the flipped design, the pilot course was considered a success and served as a prototype for other course redesigns.

Incorporating adaptive learning. Adaptive learning served as a means for delivering content outside of class, assessing student knowledge attainment, and providing formative

feedback, according to program leaders and designers. The redesign of the curriculum to use the adaptive platform started with a pilot of one course. VIS was the first to build a course using the adaptive system as a content delivery and assessment platform. FAC-3 was the next to expand the flipped model and the adaptive platform into her teaching. She first tried a portion of a course in the platform, but after very positive feedback from students, she redesigned the whole course and then did a second course in the adaptive platform. Following these successful integrations of the flipped model and adaptive platform, program leaders and designers set about redeveloping the entire pre-clinical curriculum in the adaptive platform. They broke the entire four-year, 3,000-hour program into individual pieces of content called nodes. Each node equated to approximately a 15-minute unit of content on the platform focused on one topic. DIR worked with course faculty to organize nodes into milestones, badges, and credentials that created a hierarchy of content. Each week students would work through a few milestones by reading content, watching videos, and completing quiz questions on the adaptive platform. Once students completed a credential, they were qualified to go into the clinical environment, perform the skill, and apply their knowledge on an actual patient.

Using feedback. Feedback was gathered from students, faculty, and program leaders and was used to make improvements to the curriciulum. The first release of the redesigned curriculum on the adaptive platform generated resistance and negative feedback from some students and faculty. Program leaders, faculty, and the designer gathered the feedback and made improvements. They reorganized the content by weeks, reformatted content to be text within the platform rather than PowerPoint slides, and increased the number of assessments to have four to six randomly drawn questions per node of content. The improvements were released to the

second cohort with very positive results, according to students, faculty, and program leaders interviewed.

Benefitting from the redesign. The faculty members, program leaders, and the designer all stated the redesigned curriculum was considerably better than the previous version of the curriculum, even though redesigning the curriculum and creating it in the adaptive platform was very time consuming. DIR said students are now very receptive to the platform and are spending more time on it. VIS also noted that it was easier to keep current because all topics were indexed and organized in small chunks that could be updated when needed.

Using active, collaborative learning. Classroom time was available for active, hands-on application of knowledge and more collaboration through student-faculty interaction because of the redesigned curriculum. Faculty interviews as well as observations indicated class time consisted of a variety of active learning strategies, including discussion, case study research, presentations, small group work, demonstrations, hands-on practice, quizzes, peer review, faculty coaching, and so forth.

Flipped Curriculum Design

The second major category of findings from this study relates to the flipped curriculum design. The flipped model enabled the adaptive and active elements to be incorporated into the curriculum design and also added benefits and challenges. Moving to a flipped design signaled a shift away from teacher-driven lecturing to student-driven study outside of class and teacher-facilitated, collaborative, and active classroom learning. The faculty and students interviewed indicated the flipped model allowed students to study material ahead of class at their own pace. Students could then come to class prepared to participate in hands-on application of their learning and receive frequent and personally meaningful feedback from faculty and peers.

Observations confirmed active application of knowledge and frequent, personal feedback. Themes pertaining to the flipped curriculum design included self-study, application, and feedback; faculty and student interaction; rewarding teaching experience; self-directed learning challenges; faculty time requirements; and student and faculty resistance.

Self-study, application, and feedback. Faculty members and students interviewed indicated that studying the content then applying what they had learned in class and getting feedback from others helped students learn better and retain what they were learning. Students spoke of the desirable combination of learning enabled by the flipped model: reviewing the content and taking assessments on the adaptive platform, applying what they were learning in the classroom, and receiving personalized feedback from faculty. STU-2 and two of the faculty members interviewed said this design of the curriculum is helping students retain what they are learning many months later and that retention is demonstrated through student performance in clinicals.

Student and faculty interactions. Faculty and program leaders spoke to how the flipped model opens up class time to allow faculty members to interact with students on a personal level. Interviews and observations indicated faculty members facilitated student application of what they were learning. Faculty members walked around the class to observe and give personalized feedback on an individual level.

Rewarding teaching experience. VIS and all three faculty members indicated that teaching was more rewarding and enjoyable in the flipped model because of the increased interaction with students and opportunities for one-on-one coaching. FAC-2 said he had the opportunity to see the students progress on a granular level. They were more engaged in their

learning, asked more questions, and critically thought about what they were learning and doing in the program.

Self-directed learning challenges. DIR, FAC-2, and STU-2 all spoke of the challenge of self-directed learning and its reliance on students to take the time and effort to study the material outside of class and to ask questions if they did not understand. While the program policy that required students to attain a certain percentage on their adaptive assessments in order to participate and receive a grade on their in-class work was successful in having students complete the assessments, STU-2 and DIR said they knew some students did not read the material. They instead skipped directly to the assessment questions and would repeat the questions until they guessed the correct answers. This was especially problematic the first year of the redesign when there were fewer assessment questions, but these challenges have been reduced now that there are more questions and less likelihood that students will get the same question on their next attempt at the quiz. While FAC-2 voiced concerns that students may not understand what they were studying, students interviewed said they liked being able to go over the material in advance of class so that they could either ask questions during class or send an email to the professor for clarity.

Faculty time requirements. All three faculty members interviewed indicated it required significant amounts of time to redesign course content for the adaptive platform and to prepare the in-class sessions for the flipped model. FAC-3 indicated she would spend eight to 10 hours preparing one hour of content on the adaptive platform; this included time she spent in redesigning the content and the time she spent putting the content into the adaptive platform. ID said she spent approximately four hours creating one hour of content on the platform. Planning

active learning classroom sessions also took considerable faculty time. FAC-2 said it would take him approximately two to four weeks to develop an in-class session.

Student and faculty resistance. VIS, FAC-1, and FAC-2 shared that they saw faculty resistance to the change away from traditional faculty-led, lecture-based teaching to student-driven, active, collaborative learning. FAC-2 and STU-2 also indicated that students were initially resistant to the change to student-driven learning. FAC-2 said that students wanted to receive material passively, while STU-2 spoke more about the design and organization of content on the platform as being problematic for students. STU-1 and STU-2 indicated they witnessed no resistance in the second year after the redesign of the curriculum.

Adaptive Learning Expereinces and Perceptions

The third major category of findings that arose from interviews with program leaders, faculty, and students was that the adaptive platform introduced a number of advantages over the previous delivery method. Themes within the category include personalized learning, self-paced learning, frequent assessment and immediate feedback, insights from analytics, and learning effectiveness and student satisfaction from good instructional design.

Personalized learning. Program leaders and the instructional designer indicated the adaptive platform creates a personalized learning path for each student based on their knowledge level. VIS described how students with less background knowledge would spend more time in the platform to reach the knowledge level of a student with prior knowledge, but that they could catch up. The system gives every student the opportunity to excel based on the effort they put in.

Self-paced learning. The adaptive platform allows students to study the material at their own pace. STU-2 indicated how she liked being able to focus on the areas she did not know and spend less time on the things she understood. FAC-3 described how she encourages students to

take the assessments more than once to continue to test themselves and their understanding. While students set the pace of their learning, the adaptive system as well as the requirements of the program make students take responsibility for their learning.

Frequent assessment and immediate feedback. The adaptive system uses frequent assessments with immediate feedback, generating considerable amounts of performance data on student learning. Program leaders, faculty, students, and the designer emphasized how the adaptive system lets students and faculty members know on a continual basis how well each student is learning the material and attaining the learning objectives for every piece of content in the curriculum.

Insights from analytics. Analytics data allow educators to gain insights into what and how students are learning. In addition to assessment scores, the adaptive system also collects student usage data. Together, these data provide faculty members and program leaders with a detailed view of where each student is excelling or struggling. The data can also aid analysis of each assessment question. VIS, FAC-3, and ID spoke to how faculty are able to monitor students' progress, activity, and problem areas to know exactly how students are doing at any moment in the course, and then faculty can provide interventions or re-address content or misconceptions in class when needed.

Learning effectiveness and satisfaction from good instructional design. Using instructional design principles in the design of instruction aids learning. The process of rethinking, reorganizing, and redeveloping the curriculum for the adaptive platform increased the quality of the design. DIR and ID indicated that when the content was added to the adaptive platform, it was aligned to learning objectives and meaningfully organized by credential, badge, milestone, and node to help the students to scaffold their learning to attain the knowledge they

needed to be successful in the program. FAC-3 and STU-2 said the frequent assessment and immediate feedback helped students learn more. STU-2 said she was more motivated to continue working on the system because of the affirmation she received from the system as she completed assessment questions.

Active and Collaborative Classroom Learning Experiences and Perceptions

Faculty and student experiences and perceptions with active and collaborative learning was the fourth general category of findings stemming from the research study. Program leaders, faculty, and students described class sessions as a time for students to apply actively and articulate what they were learning, evaluate their own and their peer's progress, and receive personalized coaching and feedback from faculty members. Faculty and DIR indicated it takes time to plan and create active and collaborative class sessions, but they created standardized templates and a list of active learning practices to provide guidance to faculty in designing their class sessions. Themes pertaining to active and collaborative classroom learning experiences and perceptions include assessment, student participation, rapport, formative feedback, collaboration, and dialogue.

Assessment. In the active, collaborative classroom, there are multiple ways for students to demonstrate their understanding. Classroom observations and interviews indicated several assessment techniques, such as taking quizzes, performing dental procedures, completing case studies and giving presentations in small groups, and doing in-class polls. Each method also included means for immediate feedback.

Student participation. Active learning in the classroom relies upon students actively participating in their own learning, which is not always well-received by students. FAC-1 and FAC-3 spoke to students pushing back and asking the faculty to do more teaching. FAC-1

pointed out that students do not realize how much the faculty member works to structure learning materials and activities to create a worthwhile learning environment, while FAC-3 mentioned students in today's active classroom do not know what it is like to have four hours of lecture, as there had been in the old curriculum design. Both FAC-1 and FAC-3 indicated how they now work in partnership with students to facilitate learning, but students have to take some ownership.

Rapport. Active classroom sessions provided opportunities for students and faculty members to build relationships and rapport. During classroom observations, faculty members were observed showing interest in students, sharing personal stories, asking questions unique to individual students' interests, and coaching individual students on their techniques. Students helped each other, provided feedback, and enjoyed shared accomplishments, particularly in their small groups.

Formative feedback. Individualized formative feedback was incorporated into active classroom sessions in several ways. FAC-2 and FAC-3 described giving personalized feedback to students through coaching and professional tips. Another means of personalized feedback was through the use of rubrics which first required students to complete a self assessment, then peer assessmemt, and finally have a faculty member assess their work. VIS, FAC-1, and the dean all emphasized how the immediate, specific feedback helped guide student development and growth as professionals. STU-1 indicated how helpful it was to receive all of this feedback as she honed her knowledge and skills.

Collaboration. Student interviews and observations indicated students benefitted by collaborating with each other in the classroom. Students supported each other, asked guiding

questions, and taught material to each other. STU-2 noted the value she received from hearing other students' solutions to cases, and STU-1 said she liked how students helped each other out.

Dialogue. Both students mentioned how they benefitted by being able to express their understanding of material and discuss how they completed assignments with other students. STU-1 spoke to the value in telling what she learned from the lessons and how having to teach others reinforced whether she knew the material or not. STU-2 pointed out how she has learned to think more critically because of the questions other students have asked her and how she has learned more because of hearing things that others learned from a lesson—things that she may have missed.

Preliminary Outcomes

The redesign of the pre-clinical curriculum is not yet finished; therefore, outcomes data are not complete or conclusive. However, there are early positive indications from all of the changes made to the curriciulum and delivery methods. FAC-3 said students are performing at or above the levels of previous classes on the Objective Structured Clinical Exam, a standardized test. DIR analyzed tagged questions in written exams and said current students are performing better in many areas when compared to previous cohorts. Faculty and program leaders have noticed other indications which suggest outcomes have improved following the redesign. VIS said students are finishing course material in less time and completing two to four times as many procedures as they had in the old curriciulum. FAC-3 said she observed fewer course failures now than previous cohorts. Additionally, she said students are able to apply what they are learning and write up patient cases and treatment plans much better than prior cohorts.

Conclusions and Discussion

The conclusions organize under four major categories: the redesign of the curriculum, the flipped curriculum design, the adaptive learning experiences and perceptions, and active and collaborative classroom learning experiences and perceptions. Taken separately, each of these elements may reap benefits; however, combining all four helped produce a greater positive impact, as evidenced by participant interviews.

The first conclusion to be drawn from this study is that the redesign of the curriculum resulted in a much better curriculum. This was a radical revision of the curriculum structure—a complete unbundling and rebundling of all content, across all courses. The new curriculum was recreated not through siloing content around themes, such as fillings or teeth enamel, but by stripping content coverage across all areas of the program. In the first semester, students gained introductory knowledge of all aspects of clinical dental medicine. As they advanced to the second semester, they learned a little more advanced knowledge across all aspects of dentistry. As they moved further along in the program, they advanced their level of mastery. This curriculum design served to scaffold the instruction to the students' increasing understanding. The curriculum advanced as they advanced through the program. This was a bold departure from the standard structure of educating dental students.

Program leaders, faculty, and curriculum designers redesigned the curriculum of this graduate medical program to be integrated across specific disciplines and centered around patient care. They created the curriculum to be student-centered, hands-on, chunked, aligned, scaffolded, and more efficient in moving students into a clinical setting prepared to apply their knowledge. The new design reduced student time to learn the content and enabled them to enter the clinical environment sooner. The mapping process was needed in order to develop the

content effectively on the adaptive learning platform. The revised content was concise and well-organized, aligned with learning objectives, and followed by assessments that measured student attainment of the learning objectives. Assessments provided immediate feedback including guidance for wrong answers and positive reinforcement for correct answers. This immediate feedback supported students who were studying content on their own and helped guide and encourage students to study effectively. Program leaders required that students achieve a certain percentage on the adaptive learning assessments before participating in and receiving credit for in-class activities and projects, which reinforced completing the readings and assessments before class. Students came to class, applied what they were learning, and received personalized feedback from faculty and peers. Interaction between faculty and students in the active classroom allowed faculty to guide student learning and share professional dental practices. The faculty found teaching in this environment more rewarding because of the increased interaction and close relationships that could be built.

It is the good design used in the redesign of the program that has had the most impact in making this an effective program. The breaking down of all content into 15-minute nodes, associating each node with a learning objective, providing ways for students to apply their knowledge and receive feedback, and finding ways for students to demonstrate attainment—all of this was well designed, according to instructional design principles (Bransford et al., 2000; Dick & Carey, 1996; Fink, 2003; Gagne et al., 1992; McKeachie & Svinicki, 2006; Quality Matters, 2015). The way it was implemented with training, preparation, gathering feedback, and making improvements also was well designed.

Next, not only does this study support the conclusions of Bowen et al. (2012) and Lovett et al. (2008) which indicated that learning time can be reduced through the effective use of

adaptive learning, this study also clarifies what is needed to make learning more efficient. The findings of this study would suggest that mapping the content—aligning content to learning objectives, eliminating redundantcy, filling content gaps, and assessing students after every node—was key to making learning more efficient. Curriculum designers seeking to decrease content learning time should apply these curriculum mapping strategies when creating adaptive courses to streamline content and increase student learning efficiency.

The other components of the design, adaptive system, active/collaborative, and the flipped model, were all individually important and added benefits to learning. Had they been poorly designed, there would be no value to them. For learning effectiveness, proven educational practices must be used in the design and facilitation of the course content delivery, practical application of knowledge, collaboration among students, assessment, and feedback. This program did use good design practices. Because of that, the flipped, adaptive, and active/collaborative components did add value, when considered individually. When combined, the whole was greater than the sum of its parts.

The redesign of this program was resource-intensive. It took five to seven years to redesign the curriculum and implement the adaptive and active, collaborative classroom learning into the two-year pre-clinical part of the program. Faculty members, program leaders, and design staff spent myriad hours designing, developing, and refining this program. Could the value be attained at a lesser investment of resources? In the case of this program, the redesign and integration of the program curriculum was necessary to fill gaps, reduce redundancy, and focus on the needed content and concepts. All programs should routinely review, update, and improve curricula utilizing instructional design principles to align content, application, and assessment to program goals and course learning objectives. The way leaders of this program

indexed all the content was a considerable investment of time but necessary in order to focus what was being taught on what was needed. That investment will continue to reap rewards long into the future, as the program will be easier to review and revise because it is all indexed.

This program contained a considerable amount of discreet knowledge to be learned by the students—10,000 nodes of content. Students must understand the human body, growth, deterioration, and diseases, among other things, that can impact the care they provide their future patients. The adaptive platform presented content personalized to fill gaps in each student's understanding. It is an efficient way for students to learn the content. Further, the mandate of attaining at least 80% on the quizzes to participate in required classroom learning activities provided the enforcement for full participation on the part of the students.

This program required the practice of fine motor skills and precision in using sharp instruments on humans. It also required the students learn how to diagnose complex medical problems and develop an appropriate treatment plan. The students required the oversight of expert practitioners to guide not only their hand-skills but also their thinking as they reasoned through complex health issues that were presented to them. In their future work, they will be required to diagnose and treat patients who present multitudes of symptoms and combinations of health problems. Identifying causes of symptoms and recommending treatment requires thinking through many possible causes to identify the true causes and come up with the best treatment plan for the individual. The treatment plan could have life-altering implications for future patients. The students benefitted greatly by being able to talk through the analysis and diagnosis with other students to hear their reasoning, and then talk with the experts—the faculty—who helped the students hone and refine their reasoning and critical thinking skills to diagnose and treat patients more accurately.

The next conclusion is that the combination of adaptive learning and active, collaborative learning in a flipped model created an optimal learning environment for the students. In this dental medical program, the use of both the adaptive learning system and active, collaborative learning in the classroom is very beneficial and would appear to provide the maximum learning effectiveness to prepare these students for their future careers.

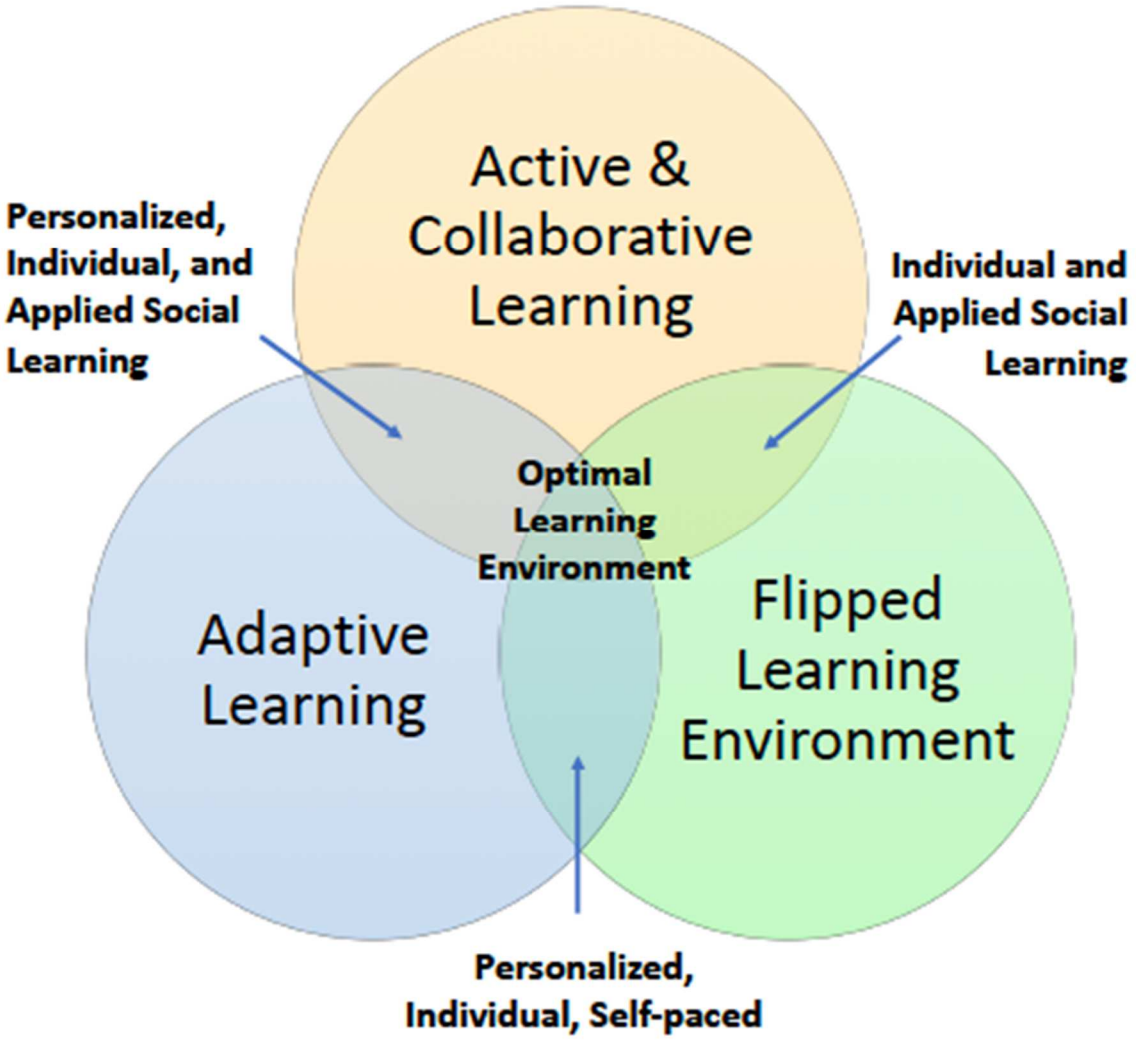

Figure 1. Venn diagram of learning environment. Copyright 2019 by Barbra R. Kerns.

The flipped curriculum design enabled the benefits of the adaptive system and the active, collaborative classroom. Although faculty, administrators, and students were initially concerned

that the students would not receive all the content they needed if the program was changed from traditional lecture to flipped learning, the mapping and the careful redesign of the curriculum in the adaptive platform resulted in students being able to grasp the content on their own, with limited coverage of content in the classroom in the form of content reinforcement. Students demonstrated they were learning the content through a variety assessments, both through quizzes in the adaptive platform and other types of assessments in the active classroom.

The adaptive system used in this case provided many benefits to learning. The adaptive learning platform provided personalized learning paths based on each student's initial assessment of prior knowledge, and these learning paths efficiently guided the students through units in which they were not yet proficient. The assessments in the system effectively supported learning and retention of knowledge and measured student attainment of the learning objectives. Further, analytics gave faculty and program leaders insights into how and what students were learning, enabling faculty and leaders to provide assistance to students when needed. The adaptive content and assessments used in this program were well designed, which made this a successful implementation. VIS worked with the adaptive company to explain his vision of the adaptive system and how it would work to deliver content and assess students. The company president met with him several times to refine the system his company was building. However, other institutions have had poor experiences in their use of adaptive systems, possibly due to the design of the content or the implementation of the platform (Griff & Matter, 2013; Yarnall et al., 2016). This case study highlighted the positive developments that can occur when adaptive learning companies partner with college and university educators to build adaptive systems and courseware tailored for the needs of the academic programs.

Active and collaborative learning played an important role in increasing learning effectiveness for the students in this study. Active and collaborative learning in the classroom provided multiple ways for students to demonstrate what they were learning. Active classroom learning required that students be active participants and take ownership in their own learning. Faculty and student interactions that took place in active learning classrooms helped build rapport between faculty and students and among students. Personally meaningful formative feedback helped guide the development and growth of the students. Active, collaborative classrooms offered faculty the opportunity to coach and guide students as they were practicing using their newly acquired knowledge and skills. Students in this study indicated collaborating, interacting, and being able to dialogue with other students and express their understanding benefitted their learning, which supports social development theory.

Implications

Learning is complicated, and learning environments are often diverse and entangled networks of competing factors. This case study is a classic example of a complex system with several compounding variables, making it difficult to determine direct cause and effect relationships. However, the purpose of the study was not to distinguish exactly how much was learned through each aspect of the curriculum design but rather to gain an understanding of faculty and student experiences and perceptions of the program. There are some inferences that can be drawn.

First, educators looking to adopt adaptive learning in their programs must evaluate both the adaptive learning system functionality as well as the adaptive learning content before chosing a system or courseware content. Leaders of the program in the case study chose an adaptive system that was open and they built their own courseware. Designers of the adaptive content

carefully structured and organized the content on the system to target precisely the learning objectives for the program. Adaptive course content is available in some subjects for purchase as courseware, while other subjects must be created by the educator. Faculty and program leaders who are evaluating off-the-shelf adaptive courseware should closely assess how well the courseware aligns with the needs of the academic program and the expectations of the faculty. Further, faculty will want to examine the content within the adaptive course and understand how well it maps to learning objectives and assesses student attainment of those objectives. Lack of alignment of adaptive courseware content to faculty intentions for the course contributed to negative findings in the studies by Griff and Matter (2013) and Yarnall et al. (2016). For faculty members and curriculum designers who are considering developing courses on an adaptive platform, they should evaluate how the system allows them to organize content, assess students, and route students on a personalized learning path.

Next, the students in this dental medical program consisted of highly intelligent, motivated, and well-prepared students who had already demonstrated they could be successful in college because they had completed their bachelor's degree. Arguably, these students could succeed in practically any learning environment. Other student populations may be less motivated to participate and show greater resistance if expected to take ownership and actively participate in their learning. One way to reduce resistance is by building rapport. Faculty and student interactions in active learning classrooms can help build rapport, but the faculty member must guide the development of good rapport. Showing interest in students, giving them respect, and encouraging their participation were some of the ways faculty members in this program built good rapport. Faculty members who are new to active learning classrooms will want to consider

ways they can build rapport with and among their students prior to the first active learning session.

Individual personalities and preferences of each student may point to some methods of learning as being more effective than others. Of the two students interviewed, one student seemed to attribute the majority of her learning to the adaptive system. STU-2 seemed to enjoy going through the content on the system, completing the quiz questions, and receiving feedback on her responses. She said it was motivating because the system gave her positive comments when she answered correctly and provided hints and guidance if she answered incorrectly. When she spoke of the classroom activity and collaboration, she was not as enthusiastic. Conversely, she spoke very highly of being able to go through the adaptive platform at her own pace and review the things of which she was unsure before answering questions or coming into class. Whereas STU-1 may have had positive things to say about the adaptive platform as well, she was more enthusiastic about being able to discuss concepts with fellow students. She seemed much more extroverted and social and appeared to gain her energy from interacting with others. She spoke more higly of social interactions with students and faculty as helping her learn the material in the program.

The findings of this study supported social development theory and the benefits of social learning. Students in this study indicated they enhanced their cognitive abilities by collaborating and interacting with each other, practicing their learning, and receiving personalized feedback from their faculty members and peers. Active and collaborative learning provides multiple ways for students to apply what they are learning, receive personalized feedback, and enhance their learning through interaction and dialog. Both students mentioned the appreciation they had and value they received from having close contact and good relationships with their faculty members.

Because educators know that different students learn in different ways, they realize that using multiple methods of teaching material and various ways for students to practice their learning and receive feedback leads to better learning. Adaptive learning systems used in conjunction with active, collaborative classroom learning provide a broad expanse of effective learning and assessment opportunities to meet various learning preferences.

How could the lessons learned through this case study benefit the broader challenges of society, including large problems such as access, affordability, scarcity? This manuscript opened with the concern of the rising costs of higher education and the increasing demands on colleges and universities to educate people to be able to handle the evolving challenges of the world. However, access to a college education is out of reach for many people. Access to a higher education could be defined as those who seek a college degree being able to attain one if they do the necessary academic work in the time that is required. This assumes several things, including 1) the individual can afford college tuition, fees, and the expenses to support themselves while seeking the degree and 2) the individual has the time and ability to take the courses when and how they are offered. There are certainly other ways of defining access to higher education, but these give some broad categories to consider and speak to the concept of scarcity. Scarcity is associated with having less than one feels he or she needs and could refer to time, money, and so forth (Mullainathan & Shafir, 2013). Adaptive learning platforms may be able to help with the problem of scarcity. Adaptive systems provide students flexible, personalized, self-paced learning with feedback. Adaptive learning has been recommended as a potential means for educating those who have constraints on their time and mobility (Dziuban, Moskal, Cassisi, et al., 2016). The findings of this case study, while not focused on identifying means of educating those with time and access constraints, did indicate that the adaptive learning courseware used in

this program had high educational effectiveness outside of a campus classroom. The adaptive system could help graduating high school seniors who may not be academically prepared for college-level courses. The adaptive courseware could be designed to bridge the gap for students wanting to enter college who may be lacking adequate skills in math, reading, writing, science, or other academic disciplines.

Any program looking to emulate the design strategies used in this program should start with the end goal in mind and carefully consider the requirements for the success of their students when they graduate from the program to understand if the curricular elements are suitable and advantageous for meeting their students' needs. For example, an English program focused on developing excellent writing skills in their students may benefit by having an adaptive learning platform deliver content for introductory grammar and writing mechanics. They may even consider using machine grading and student peer review of student essays for multiple feedback opportunities. Program leaders of such an English program may want to incorporate occasional live interactions to discuss and analyze thematic development or writing style. Live interactions could be mediated by technology such as a web conferencing system. As another example, a mathematics program may benefit by developing all content and assessments in an adaptive platform and incorporate occasional live interactions for discussion of problem-solving strategies and have opportunities for tutoring if students are struggling. These are just a few examples.

Suggestions for Further Research

This study has surfaced the need for additional research relative to active, collaborative learning used in conjunction with adaptive learning in a flipped model. Program leaders of this case study were still completing the redesign of the curriculum; therefore, outcomes data

collected in this study were not complete. Preliminary data were generally positive, suggesting students performed equally well or better on standardized tests, completed content faster to allow for more hands-on practice, had higher pass rates, had better retention, and attained more comprehensive understanding than students in previous cohorts. However, these data were not fully conclusive. More research on the outcomes of this program is needed to confirm that students achieve gains in academic performance, retention, and other valued metrics.

This study focused on a graduate medical program. Accpetance into this program was highly competitive, resulting in a student body of high-achieving and motivated students. More research is needed to understand if programs with less motivated students would have similar findings as those of this program.

Research on other disciplines would be warranted to understand if findings are comparable, particularly in areas that are more theory-based. Similary, research on undergraduate students is needed to understanding if undergraduate students and faculty would have similar perceptions of the combination of adaptive learning and active, collaborative classroom-based learning offered in a flipped model.

Additional research on the outcomes of this program will help elucidate the effectiveness of this design. Research on other programs using adaptive learning along with active, collaborative learning will help increase the understanding of the impact of this curriculum design on other populations of students and other disciplines. Further study in these areas will help determine the generalizability of this model of learning.

Summary

Advances in technology like adaptive learning systems are creating opportunities for educators to increase the potential of student learning. This case study of a program that was

redesigned to use adaptive learning outside of class and active and collaborative learning in the classroom in a flipped environment has provided two overarching conclusions and some suggestions for further study.

First, this was a radical redesign of the curriculum—unbundling and rebundling—integrating content across all aspects of dentistry. The redesigned curriculum was centered around patient care and scaffolded to meet the needs of the learner. In the words of FAC-1, it turned dental education "on its ear." The whole program was broken down into its 10,000 nodes of content. Every sub-topic, specialized discipline, general concept, and key idea was separated and indexed on a comprehensive map of the entire curriculum. It was then reorganized around patient care in a stepped manner that led students to a deeper and more comprehensive understanding as they progressed through the program. This radical redesign led to the elimination of redundancy and the filling of gaps in the content. The restructured content, centered on patient care, gave students a more meaningful introduction to the material and quicker access to hands-on dentistry work in the dental clinic, which students and faculty appreciated, and helped affirm students' decisions to go to dental school and become dentists. How might this benefit other programs? Should they invest years in unbundling and re-bundling their curriculum? If they want a highly focused, measurable, and easily updatable curriculum, the answer is yes.

Second, the combination of adaptive learning outside of class and active and collaborative learning designed with a flipped model was an optimal learning environment. Students benefitted by interacting and collaborating with other students in the classroom and receiving feedback from peer and faculty reviews of their work. They found it motivating and supportive to discuss course work and cases with other students and enjoyed being coached by

the faculty members circulating among the students in the classroom. The adaptive platform increased the efficiency of learning. Students learned what they needed to learn in a shorter amount of time. The adaptive learning system provided the ability to deliver well-designed content outside of class with an efficient and personalized learning path, frequent assessments, and analytics on student activity and achievement. VIS compared standard learning to adaptive learning as being like driving a pedal car versus driving a car with a fast engine. In some academic disciplines, programs could be delivered using just the adaptive platform. Well-designed and implemented adaptive courseware can address constraints of mobility and time. It can be delivered in a completely online format and used as the primary means for content delivery, practice, and assessment of student learning.

This case is a classic example of a complex system. Complex systems are diverse, interdependent, networked, and adapting (Page, 2011). It is difficult to determine cause and effect because there are multiple causes and multiple variables. One might infer that some aspects of learning efficiency are due to the redesign of the curriculum. The students' improved ability to apply knowledge is due in part to the capabilities of the adaptive system, to the collaborative and active learning environment in the classroom, and to the rapport and relationships built with the faculty. The multifaceted design of this curriculum stood to serve a wide variety of needs of the students in this complex system.

As educators look to advance the capabilities of human learning, they should consider good design, adaptive learning technology, active learning, and faculty-student relationships. The findings of this study may provide strategies other institutional leaders may consider implementing within their programs. Conclusions of this study may help inform other program leaders and faculty members who are considering methods for enhancing student learning in

academic programs. Combining adaptive learning with active, collaborative learning can offer efficient delivery of content, frequent assessment, powerful data, application of knowledge, and personalized feedback; however, good curriculum design and good relationships play key roles in program effectiveness.

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APPENDIX A: REQUEST TO COLLEGE DEAN FOR APPROVAL TO CONDUCT STUDY

Dear Dr. Friedrichsen,

I am a Ph.D. student at Indiana State University working on my dissertation on adaptive learning implementation. Specifically, I am studying course design that combines adaptive technology with effective classroom practices like collaborative and active learning. I learned about your programs and their use of adaptive learning from colleagues at Educause as well as representatives of Realizeit. I viewed the university website, several videos, and web articles about your programs and am interested in researching your program as a case study. For the study, I would like to come to the campus and interview the associate dean as well as other faculty members and staff who were involved in re-designing the program to utilize adaptive learning courseware and active, collaborative classroom learning. I would also like to observe current classes and interview faculty members who are teaching in the program and current students and graduates of the program. I would follow IRB-approved research methods including consent. For students who do not grant consent for being observed in the classroom, I would not observe them and would not make notes or record any information about them. Would you grant your approval for me to conduct this study?

If approval is granted, I would like to contact 2014 and 2015 graduates of the program for their input and would need to know who I should contact for names and contact information for all 2014 and 2015 graduates of the program.

As some background information about me, I work full-time as the executive director of

Learning Design and Technology at Bradley University. I have completed the coursework for my Ph.D. program at ISU and completed my dissertation proposal. I am most interested in what your institution is doing because of the program design that incorporates both technology and face-to-face interactive learning.

Thank you in advance for your consideration. I look forward to hearing from you.

Sincerely,

Barbra Kerns

APPENDIX B: CONSENT TO PARTICIPATE IN RESEARCH (INTERVIEW)

Case Study of a Flipped Curriculum Using Collaborative and Active Learning With an Adaptive Learning System

You are asked to participate in a research study conducted by Barbra Kerns and Ryan Donlan from the Department of Educational Leadership at Indiana State University. The study is being completed as part of a dissertation project. Your participation is entirely voluntary. Please read the information below and ask questions about anything you do not understand before deciding whether or not to participate.

You have been asked to participate in this study because you are part of the graduate medical program that has implemented a curriculum design of active and collaborative learning in the classroom and adaptive learning outside of the classroom.

The purpose of this study is to understand student and faculty experiences in this program and to explore the different elements of the program design and the perceived value each element brings to individuals. This site was selected because of the design choices to combine adaptive courseware outside of class with active and collaborative classroom learning. Your program was recommended by higher education technology professionals.

If you volunteer to participate in this study, you will be asked to participate in an interview that will be approximately one hour long. During the interview, you will be asked if the interview may be audio recorded. If approved, a digital recorder would be used. The researcher may also take notes during the interview.

There are no foreseeable risks or discomforts in participating in the research.

There are no direct benefits to participants. This program and other programs may benefit in the future by the findings of this study.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by using each participant's initials that is only associated with a code key which will be held by the researcher. The only identifiers directly associated with the interview records will be the initials. Digital audio recordings will be transcribed and then identified with initials associated with a code key to be held by the researcher. Recordings will then be deleted.

You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw up to 24 hours following the interview without consequences of any kind or loss of benefits to which you are otherwise entitled. You may refuse to answer any questions you do not want to answer. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

If you have any questions or concerns about this research, please contact Barbra Kerns by phone at (309) 696-3618, or email bkerns2@sycamore.indstate.edu, or contact Ryan Donlan by phone at (812) 237-2821, or email ryan.donlan@indstate.edu.

If you have any questions about your rights as a research subject, you may contact the Indiana State University Institutional Review Board (IRB) by mail at Indiana State University, Office of Sponsored Programs, Terre Haute, IN 47809, by phone at (812) 237-8217, or e-mail the IRB at irb@indstate.edu. You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent

committee composed of members of the University community, as well as lay members of the community not connected with ISU. The IRB has reviewed and approved this study.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Printed Name of Subject

_____ _____

Signature of Subject Date

APPENDIX C: CONSENT TO PARTICIPATE IN RESEARCH (ALUMNI)

Case Study of a Flipped Curriculum Using Collaborative and Active Learning With an Adaptive Learning System

You are asked to participate in a research study conducted by Barbra Kerns and Ryan Donlan from the Department of Educational Leadership at Indiana State University. The study is being completed as part of a dissertation project. Your participation is entirely voluntary. Please read the information below and ask questions about anything you do not understand before deciding whether or not to participate.

You have been asked to participate in this study because you are a graduate of the graduate medical program that has implemented a curriculum design of active and collaborative learning in the classroom and adaptive learning outside of the classroom.

The purpose of this study is to understand student and faculty experiences in this program and to explore the different elements of the program design and the perceived value each element brings to individuals. This site was selected because of the design choices to combine adaptive courseware outside of class with active and collaborative classroom learning. Your program was recommended by higher education technology professionals.

If you volunteer to participate in this study, you will be asked to complete a two-question survey and you will be invited to participate in a phone interview. If you agree to the interview, you will be contacted to let you know whether or not you have been selected.

There are no foreseeable risks or discomforts in participating in the research.

There are no direct benefits to participants. This program and other programs may benefit in the future by the findings of this study.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of assigning each participant's initials that are only associated with a code key which will be held by the researcher. The only identifiers directly associated with the interview records will be the initials. Digital audio recordings will be transcribed and then identified with initials associated with a code key to be held by the researcher. Recordings will then be deleted.

You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw up to 24-hours following the phone interview without consequences of any kind or loss of benefits to which you are otherwise entitled. If you refuse, you will not be interviewed and any collected interview data will be destroyed. There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

If you have any questions or concerns about this research, please contact Barbra Kerns by phone at (309) 696-3618, or email bkerns2@sycamore.indstate.edu, or contact Ryan Donlan by phone at (812) 237-2821, or email ryan.donlan@indstate.edu.

If you have any questions about your rights as a research subject, you may contact the Indiana State University Institutional Review Board (IRB) by mail at Indiana State University, Office of Sponsored Programs, Terre Haute, IN 47809, by phone at (812) 237-8217, or e-mail the IRB at irb@indstate.edu. You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the

community not connected with ISU. The IRB has reviewed and approved this study.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Printed Name of Subject

_____ _____

Signature of Subject Date

APPENDIX D: RESEARCH PROTOCOL FOR INTERVIEWING PROGRAM VIS

Time of interview:

Date:

Place:

Interviewer:

Interviewee:

(Briefly describe the project)

Program Background Questions

1. Who are the students? demographics (age, hometown, socio-economic, ethnicity, employment, prior education, academic preparation, test scores, etc.); career aspirations, etc.
2. What are the curricular goals of the program? (What will students know and be able to do once they graduate?) (content, knowledge, skills, soft skills, attitudes, etc.)

What elements were included in the design of this program curriculum and why?

3. When did the program start (originally and also in the current design model)?
4. When was it redesigned?
5. Why was it redesigned?
6. What design decisions were made? Why were they made this way?

7. What do you believe are the most important elements of this program design? What about them makes you think so?
8. How many courses (all?) use adaptive learning? Why?
9. What is the classroom portion of class like? (active, hands-on, experiential, social, collaborative?)
10. Did you have any challenges you struggled with when thinking about how to design this program?

Have student outcomes changed following the curriculum redesign? If so, how?

11. What have been the results of this design change? What were the outcomes before, and what are they now? (student performance data/grades, standardized test scores, retention)
12. Has student performance increased/decreased/stayed the same? How much did it change?

How do students and teachers describe their perceptions of and experiences with adaptive learning in the program?

13. What has been the response of the students—do they like it; are they more engaged or about the same; are there any complaints?
14. What impact has adaptive learning had on the program? Students? Faculty? Institution?
15. What do the employers of the students that graduate from this program say about your students? Has employer feedback changed from before the redesign to after?

How do students and teachers describe their perceptions of and experiences with active learning

and collaborative learning in the program?

16. To whom should I talk to learn more about the elements of the program design, outcomes, perceptions and experiences of faculty and students with active, collaborative, and adaptive learning? Who might have both a favorable view and an unfavorable view? Who would have taught with the old program design and the current design?

(Thank you for participating in this interview. Your responses to this and future interviews will remain confidential.)

APPENDIX E: RESEARCH PROTOCOL FOR INTERVIEWING DESIGN STAFF

Time of interview:

Date:

Place:

Interviewer:

Interviewee:

(Briefly describe the project)

1. What was your training and experience in instructional design prior to designing the program?
2. Were you involved in the design of the first iteration of the program design? If so, how was the first design different than the redesign? What was done differently? What new things or elements were included?
3. Describe the design (the selection, structuring, and sequencing of content delivery methods, communication strategies, collaboration techniques, learning activities, assessment strategies, and so forth).
4. Where did the design come from? Why was this design chosen?
5. What are the intended outcomes of the curriculum design? Were they changed from the original design to the redesign?
6. What is learning like for the students? (What are the expected student learning

experiences?) What will students gain from this learning experience?

7. What is expected of teachers in the new curriculum design? How are expectations of faculty different from before the redesign?
8. Do you believe the design of the program accomplished all that was intended? What would you change?

(Thank you for participating in this interview. Your responses to this interview will remain confidential.)

APPENDIX F: RESEARCH PROTOCOL FOR INTERVIEWING FACULTY

Time of interview:

Date:

Place:

Interviewer:

Interviewee:

(Briefly describe the project)

1. Suppose I am a new faculty member and it is my first day teaching in the program. What would it be like?

Response to Adaptive

2. Did you teach any differently when using adaptive learning for the course? If so, how was it different or what did you do differently? What was your teaching like before using adaptive learning?
3. How did you respond to teaching with adaptive learning? What was the experience like for you? How did you feel about it?
4. Did you receive any feedback from students with respect to the adaptive content and assessments? If so, what was the feedback?

Response to active and collaborative learning

5. How did you respond to teaching in an active learning classroom? What was it like? How was it different? How did your students respond?

Curriculum re-design

6. How would you describe the design of the program? (the selection, structuring, and sequencing of content delivery methods, communication strategies, collaboration techniques, learning activities, assessment strategies, and so forth).
7. Why was this design chosen?
8. What are the intended outcomes of the curriculum design?
9. Did you expect any differences in student learning experiences and learning outcomes? If so, what differences did you expect?
10. What was expected of teachers in the new curriculum design? How was this a change from before?
11. What were your perceptions of the program before the re-design occurred, and how did your perceptions change?
12. What was it like teaching in this program?
13. Did anything surprise you? If so, what?
14. Describe the in-class and out-of-class experience.
15. Has your role changed? If so, how?
16. Do you like this design of the program? Is teaching in this program satisfying?
17. Do you believe the students are learning more/less?
18. Have you had any challenges? If so, what?

19. Have there been any things about the new curriculum design that have worked well? If so, what are those things?
20. Have there been any benefits or challenges with the new program design? If there were benefits, how would you describe them? If there were challenges, how would you describe them?

21. Which students or faculty members should I talk to in order to learn more about the program design, and perceptions and experiences with active, collaborative, and adaptive learning? Who will have a favorable view and who will have an unfavorable view?

(Thank you for participating in this interview. Your responses to this and any future interviews will remain confidential.)

APPENDIX G: RESEARCH PROTOCOL FOR INTERVIEWING STUDENTS

Time of interview:

Date:

Place:

Interviewer:

Interviewee:

(Briefly describe the project and define adaptive learning courseware and active and collaborative learning)

1. Suppose I am a new student and it is my first day in the program. What would it be like?

Perceptions of and Experiences with Adaptive

2. Before this program, what were your previous college courses like? Had you had a course that used adaptive courseware before?
3. What was your learning experience like when you used the adaptive courseware?
4. How did you respond to adaptive learning? How did you feel about it?

Perceptions of and Experiences with Active and Collaborative Aspect

5. How did you respond to active learning (for example, solving problems) in the classroom?

6. How did you respond to collaborative learning (working with other students to solve the problems) in the classroom?
7. Did the active and collaborative aspect of the course affect how well you learned the material? How so?
8. Have you been satisfied with what you have learned in the courses you have completed? Do you believe each course is preparing you for achieving your academic and professional goals? How so?

Perceptions of Learning Efficacy

9. How would you compare how well you are learning the material with this class (with the adaptive courseware and the active/collaborative/problem-based learning) compared to more traditional courses (reading a textbook, attending lectures, doing assignments, and taking tests)?
10. Are there elements of this program that are helping you understandand and apply what you are learning? If so, what are they?
11. Do you believe the adaptive learning system is impacting your learning in any way? If so, how?
12. How do you feel about adaptive learning?
13. Do you believe the collaborative learning is impacting your learning in any way? If so, how?
14. How do you feel about collaborative learning?
15. What does the faculty member do in class?
16. Are the faculty member's actions impacting your learning? If so, how?

17. How do you feel about what the faculty member does?
18. Since this is a flipped course, what does the faculty member do to engage or interact with students outside of class?
19. How do you feel about what the faculty member is doing outside of class time?
20. Are the faculty member's actions that happen outside of class impacting your learning in any way? If so, how?
21. If you could leave out an element of the program, would you? If so, what would it be? Why? What impact do you think that change would have on your learning?
22. If you were designing this program, would you do anything differently? What would the program be like?
23. In a sentence or two, how would you describe the program.

(Thank you for participating in this interview. Your responses to this interview will remain confidential.)

APPENDIX H: RESEARCH PROTOCOL FOR INTERVIEWING ALUMNI

Time of interview:

Date:

Place:

Interviewer:

Interviewee:

(Briefly describe the project and define adaptive learning courseware and active and collaborative learning)

1. What do you remember about your program? Is there anything that stands out about the courses you took?
2. What elements of your program helped you learn?
3. How did you feel about the different elements of the curriculum design (adaptive learning software and active and collaborative classroom learning)?
4. What aspects of the program do you believe best prepared you for achieving your professional goals?

Perceptions of and Experiences with Adaptive

5. Do you remember using adaptive learning courseware? What was it like?
6. Did it impact your learning? If so, how?

7. How did you feel about it?

Perceptions of and Experiences with Active and Collaborative Aspect

8. Do you remember participating in any active learning in the classroom, for example a time in which you worked to solve particular problems?
9. How did you respond to active learning (for example, solving problems) in classroom?
10. How did you respond to collaborative learning (working with other students, for example, to solve the problems) in classroom?

Perceptions of Curriculum Design and Learning Efficacy

11. How would you compare how well you learned the material with the adaptive courseware and the active/collaborative/problem-based learning compared to a more traditional course (reading a textbook, attending lectures, doing assignments, and taking tests)?
12. Have elements of this program design helped your understanding and ability to apply what you are learning? If so, what are they and how have they helped?
13. If you could have left out an element of the program, would you? If so, what would it have been? Why? What impact do you think that change would have had on your learning?
14. If you were designing this program, would you do anything differently? What would the program be like?
15. In a sentence or two, how would you describe the program (as it was when you attended).

(Thank you for participating in this interview. Your responses to this interview will remain confidential.)

APPENDIX I: RESEARCH CLASSROOM OBSERVATION PROTOCOL

Class:

Day/Time/Location:

Professor:

Students' year in program:

Number of students:

Anyone else in the room/role:

Observe interactions:

1. Interactions observed: student-student; student-faculty; student-content
2. Actions that are non-interactive: lecturing, independent work/reading/self-study, student presentation, other
3. Types of learning observed: faculty-led instruction; student-led student learning in groups; self-led independent learning; student (peer) teaching
4. To what extent are students focused on the course learning objectives?
5. At what level of Bloom's taxonomy is learning occurring (Cognitive complexity—knowledge retrieval, comprehension, application, analysis, synthesis)
6. Does the environment promote student ownership of learning (student autonomy—low, medium, high, unsure)
7. Level of student engagement (engaged in real learning, compliant, disengaged)
8. Are the students engaged in active, authentic conversations that support or extend learning (some, majority, all students)?

Behaviors:

Communication behaviors, patterns

Physical activity

Affective:

Uneasiness, uncertainty

Negative emotions, concern, fear, conflict

Positive emotions, joy, excitement, passion

Mood

Provide description of setting and activities:

Descriptive Notes	Reflective Notes
General:	