The Effects of Motivation on Achievement and Satisfaction in a Flipped Classroom Learning Environment

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Abstract

The flipped classroom is a blended, constructivist learning environment that reverses where students gain and apply knowledge. Researchers have provided little empirical evidence that students are more successful in the flipped classroom learning environment compared to the traditional lecture environment. The purpose of this quantitative study was to investigate the constructivist learning theory by comparing the flipped classroom learning environment with the traditional lecture learning environment. A comparison was made using posttest scores and student satisfaction with both instructional models, while considering the level of student academic motivation and pre-knowledge amongst non-science students taking an elective science course at an open-enrollment college. Participants in this study included forty-nine 18 years of age and over college students. To date, the flipped classroom instructional model has not been studied in science courses intended for the non-science major at an open-enrollment college. Using ANCOVA statistical analyses, the findings indicate that there is no significant difference in the posttest scores ($F(1,45) = .091$, $p = .765$) or student satisfaction ($F(1,45) = 1.561$, $p = .218$) between the flipped classroom and lecture learning environments while controlling for pre-knowledge and academic motivation. Because of this, it is recommended that the study be repeated with a larger sample size using a mixed-methods design with experienced flipped class instructors so that even small differences in achievement and satisfaction can be detected and evaluated.

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Table of Contents

List of Tables

Chapter 1: Introduction

The flipped or inverted classroom is a modification of student-centered instructional models that have been in existence for many years (Felder, 2012). The flipped or inverted classroom is an instructional model in which the traditional lecture is a student's homework and in-class time is spent on collaborative, inquiry-based learning (Bergmann & Sams, 2012). Student-centered instructional models, including the flipped classroom, are grounded in the constructivist theory of learning (Felder, 2012; Gordon, 2008; Perkins, 1999; Strayer, 2012). The core idea of constructivism applied to learning is that the environment is learner-centered where knowledge and understanding is socially constructed (Felder, 2012; Perkins, 1999; Sternberg, 2008).

Over the years, educators have sought methods for applying the constructivist theory to the classroom (Sternberg, 2008). Learning environments infused with technology are considered blended learning environments (Donnelley, 2010). The flipped classroom learning environment capitalizes on the increased opportunities for constructivist learning that technology has provided (Koohang, Riley, Smith, & Schreurs, 2009; Neo & Neo, 2009; Vos, van der Meijden, & Denessen, 2010). The flipped classroom could be considered a blended, constructivist learning environment (Felder, 2012; Strayer, 2012).

Before the implementation of a new learning environment, instructors need to know if students will be more successful in and satisfied with the learning environment (Strayer, 2012). One method for assessing student achievement is through summative assessments such as unit or final exams (Lavasani & Ejei, 2011; Kiriakidis, Decosta, & Sandu, 2011; Rastegar, Jahromi, Haghighi, & Akbari, 2010). Student satisfaction can be determined by end-of-course surveys that ask students about his or her perceptions of the learning environment (Fraser, Treagust, & Dennis, 1986; Strayer, 2012). However, success and satisfaction in any learning environment may be influenced by the student's individual characteristics (Baeten, Kyndt, Struyven, & Dochy, 2010; Baeten, Struyven, & Dochy, 2013).

A student's initial level of academic motivation can affect student achievement and satisfaction in a constructivist learning environment such as the flipped classroom (Hill, 2013; Jaschik, 2013; Lavender, 2005; Liu, Bridgeman, & Alder, 2012; Lopez-Perez, Perez-Lopez, Rodriguez-Ariza, 2011; Ning & Downing, 2012; Rastegar et al., 2010; Soenens & Vansteenkiste, 2005; Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009). In fact, several researchers indicated that some students were not as satisfied with the classroom flip and preferred the traditional lecture (Albrecht, 2006; Crouch & Mazur, 2001; Lage, Platt, & Treglia, 2000; Strayer, 2012; Zappe, Leicht, Messner, Litzinger, & Lee, 2009). The flipped classroom has been studied in science and economics courses at competitive universities and with academically motivated high school students where researchers reported an increase in student achievement (Crouch & Mazur, 2001; Lage et al., 2000, Mazur, 2009; Musallam, 2010; Strayer, 2012; Zappe et al., 2009). Studies have not been conducted in science courses intended for the non-science major student at an open-enrollment college. To that end, the level of a student's academic motivation may influence success and satisfaction with the flipped classroom model (Baeten et al., 2010; Baeten et al., 2013; Carini, Kuh, & Klein, 2006; Kirschner, Sweller, & Clark, 2006; Niemiec & Ryan, 2009; Lavender, 2005; Vansteenkiste et al., 2009).

Background

The flipped or inverted classroom has evolved over the years from instructional models that have included problem-based learning (PBL), inquiry learning, just-in-time teaching (JiTT), process oriented guided inquiry learning (POGIL), and Peer Instruction (PI) (Crouch & Mazur, 2001; Herreid & Schiller, 2013; Prince & Felder, 2006; Prince & Felder, 2007). The flipped classroom is an instructional model where out-of-class activities involve low-order knowledge acquisition often in the form of a vodcast and in-class time is spent doing collaborative, inquiry-based learning (Bergmann & Sams, 2012; Herreid & Schiller, 2013). Constructivism provides the foundation for these student-centered instructional models including the flipped classroom (Felder, 2012; Gordon, 2008; Perkins, 1999; Strayer, 2012). The core idea of constructivism applied to learning is that the environment is learner-centered where knowledge and understanding is socially constructed (Felder, 2012; Perkins, 1999; Sternberg, 2008). The learner develops new ideas and alters existing ideas when interacting with content and collaborating with other learners and the instructor (Felder, 2012; Perkins, 1999; Prince & Felder, 2006; Prince & Felder, 2007; Sjoberg, 2007; Sternberg, 2008).

Over the years, educators have sought methods for applying the constructivist theory to the classroom (Sternberg, 2008). The flipped classroom instructional model capitalizes on the increased opportunities for constructivist learning that technology has provided (Koohang et al., 2009; Neo & Neo, 2009; Vos et al. 2010). Instructors who infuse technology into his or her teaching are able to deliver content outside of class so that face-to-face (F2F) time can be spent interacting with the content (Bergmann & Sams, 2012; Herreid & Schiller, 2013; Koohang et al., 2009). Interactivity occurs in the F2F classroom when the students work collaboratively to solve problems, evaluate, and synthesize ideas and concepts. Learning deepens with the collaborative, interactive relationships that develop between students and teachers (Baeten et al., 2010; Brunsell & Horejsi, 2011).

Engagement in the F2F environment has been difficult to achieve because students must enter this environment with foundational concepts established (Nie, Armellini, Harrington, Barklamb, & Randall, 2010). With the proliferation of Web 2.0 technologies such as podcasts and vodcasts, delivering content prior to the F2F classroom has become easier (Herreid & Schiller, 2013; Koohang et al., 2009; Nie et al., 2010; Vos et al., 2010). Pod- and vodcasts have been found to be effective pedagogical tools, and when used in conjunction with a collaborative, engaging F2F learning environment, a "perfect storm" of technology and constructivism has produced the flipped classroom instructional model (Young, 2012). Today's students have grown up with technology and use it in their personal lives to connect with friends (Tapscott, 2009). Utilizing these native tools in a student's learning process makes pedagogical sense (Tapscott, 2009).

The student population in higher education of today has been branded the "Net Generation" (Prensky, 2001). These students are digital natives who use technology to construct their own knowledge and ideas based on the information encountered through technology and social media (Beyers, 2009; Oblinger & Oblinger, 2005; Prensky, 2001; Roberts, 2010; Tapscott, 2009). Therefore, the Net Generation of learners should be more satisfied and successful within the flipped classroom model (Beyers, 2009). However, several researchers indicated that some students were not as satisfied with the classroom flip and preferred the traditional lecture (Albrecht, 2006; Crouch & Mazur, 2001; Lage et al., 2000; Strayer, 2012; Zappe et al., 2009). The flipped classroom has been studied in courses such as microeconomics, statistics, physics, and engineering at competitive higher educational institutions and in advanced placement chemistry with academically motivated high school students where researchers reported an increase in student achievement (Crouch & Mazur, 2001; Lage et al., 2000, Musallam, 2010; Strayer, 2012; Zappe et al., 2009). There are no known studies that have been conducted in science courses intended for the non-science major at an open-enrollment college. While the academically average student may benefit from the flipped classroom learning environment, it is possible the level of a student's academic motivation may influence achievement and satisfaction with the flipped classroom model (Baeten et al., 2010; Carini et al., 2006; Herreid & Schiller, 2013; Kettle, 2013; Kirschner et al., 2006; Lavender, 2005; Ning & Downing, 2012).

Statement of the Problem

Despite the attention that the flipped or inverted classroom has been getting in mainstream media and educational blogs (WSJ, 2012; Young, 2012), researchers have been uncertain as to whether the flipped classroom environment increases student achievement (Merrill, 2008; Vos et al., 2010; Zappe et al., 2009) and student satisfaction within the learning environment (Strayer, 2012; Zappe et al., 2009) for students with varying academic preparedness and motivation levels. Student intrinsic motivation increases in a constructivist learning environment, but researchers have not indicated if student motivation mediates achievement or satisfaction in a constructivist learning environment such as the flipped classroom (Baeten et al., 2010; Sesen & Tarhan, 2010; Vansteenkiste et al., 2009; Vos et al., 2010).

The specific problem with the flipped classroom is two-fold. One problem is that there is little evidence that indicates whether students are more successful in the flipped classroom learning environment compared to the traditional lecture environment (Lage et al., 2000; Mazur, 2009; Strayer, 2012; Zappe et al., 2009). Another problem is that not all learners are prepared academically or have the motivation needed to perform successfully in the constructivist learning environment (Kirschner et al., 2006; Lavasani & Ejei, 2011; Liu et al., 2012). The level of academic motivation and pre-knowledge may influence student achievement with the flipped classroom and influence students' satisfaction with the flipped classroom (Kettle, 2013; Niemic & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009). Further, researchers have not flipped a class at an open-enrollment college in science classes where students have a wide-range of academic motivation levels. Determining whether the flipped classroom increases student satisfaction and achievement in elective science courses where students' individual characteristics vary is imperative to future applications of the flipped classroom (Herreid & Schiller, 2013; Kettle, 2013; Strayer, 2012; Zappe et al., 2009).

Purpose of the Study

The purpose of this quantitative study was to investigate the constructivist learning theory by comparing the flipped classroom learning environment with the traditional lecture learning environment. A comparison was made using posttest scores and student satisfaction with both instructional models, while considering the level of student academic motivation and pre-knowledge amongst non-science students taking an elective science course at an open-enrollment college. A minimum sample of 55 students at Pennsylvania College of Technology (Penn College) in Williamsport, Pennsylvania was needed to voluntarily enroll based upon personal interest in the course Introduction to Environmental Science (Environmental Science).

The pre- and posttest scores were recorded and compared in both the flipped and traditional learning environments. Satisfaction with the flipped classroom and traditional lecture models were measured using modified items from the College and University Classroom Environment Inventory (CUCEI) with Likert-scale response choices (Fraser & Treagust, 1986; Fraser, Treagust, & Dennis, 1986; Strayer, 2012). The level of student self-determination (motivation) is a possible covariate that may influence student satisfaction with and achievement in the flipped classrooms (Ning & Downing, 2012; Vansteenkiste et al., 2009). The level of motivation was determined prior to the commencement of the study using the Academic Motivation Scale- College Version (AMS-C) (Lavender, 2005; Vallerand, Pelletier, Blais, Briere, Senecal, & Vallieres, 1993; Vos et al., 2010).

Research Questions and Hypotheses

The following research questions and hypotheses were addressed in a science course intended for non-science major students at the open-enrollment, technical college studied.

Q1. After controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college?

H1$_0$: There is no difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in science knowledge and academic motivation.

H1$_a$: There is a difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in environmental science knowledge and academic motivation.

Q2. After controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in satisfaction between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college?

H2o. There is no difference in satisfaction with environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in science knowledge and academic motivation.

H2a. There is a difference in satisfaction with environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in environmental science knowledge and academic motivation.

Nature of the Study

This quantitative study was designed as a nonequivalent between-groups quasi-experimental design to test the constructivist learning theory by comparing the flipped classroom model with the traditional lecture model with respect to posttest scores and student satisfaction with a group of non-science students taking an elective science course at an open-enrollment college. Level of self-determination (motivation) and pre-knowledge were examined as possible covariates for student achievement in and satisfaction with the flipped classroom learning environment. For comparison, two groups of 23 and 26 students in Introduction to Environmental Science (Environmental Science) were studied. One group was taught using the flipped classroom model and the other group using the traditional lecture model. The instructors in the flipped classroom and traditional lecture classroom instructors were different. Both Environmental Science course instructors have over a decade of teaching experience and neither was the researcher in this study. For the purpose of clarity, the flipped classroom instructor will be called the flipped instructor and the traditional lecture instructor will be called the lecture instructor.

A pretest was administered to both the treatment and control students to determine pre-knowledge about Environmental Science in the flipped classroom and traditional lecture learning environments (Black, 2002; Gonzalez & Griffin, 2002). The pretest was administered during week 1 of the class offering. The pretest questions were aligned with the course outcomes. Pre-knowledge is a possible covariate for achievement and satisfaction in a learning environment and was examined initially to help answer Q1 and Q2.

The level of motivation was measured prior to the start of the semester to determine if the level of academic motivation influences student satisfaction and achievement a learning environment (Black, 2002; Gonzalez & Griffin, 2002; Kettle, 2013; Ning & Downing, 2012). As the covariate, the measurement of motivation helped answer Q1 and Q2.

Achievement was measured using the scores from the posttest and is considered the dependent variable in Q1. Students in both the treatment and control groups were measured twice, before (pretest) and after (posttest) the treatment is applied (Black, 2002). A posttest, identical to the pretest, was administered as the part of the final exam to determine content knowledge gained and ultimately, student achievement, in flipped classroom lecture environment compared to the traditional lecture learning environment. The posttest scores were used to compare student achievement in the flipped and traditional classes as indicated in Q1.

Satisfaction with the learning environments was measured using the results from the CUCEI questionnaire and is considered the dependent variable in Q2 (Fraser et al., 1986). After the completion of all course content, students in both the treatment and control groups were sent a CUCEI questionnaire via the Qualtrics survey software. The results from the CUCEI survey helped determine student satisfaction with the learning environment (Strayer, 2012). As in Q1, the levels of pre-knowledge and academic motivation are hypothesized to be covariates, and were controlled in the data analysis.

Significance of the Study

Given that researchers have provided limited empirical evidence that indicates student achievement in and satisfaction with the flipped classroom learning environment and little evidence has been provided that explains why some students are less satisfied with the flipped classroom, a quantitative study on the flipped classroom instructional model should be conducted. Most of the researchers who have reported student success and satisfaction with constructivist learning conducted studies in K-12 settings (Acat & Donmez, 2009; Araz & Sungur, 2007; Musallam, 2010; Sesen & Tarhan, 2010; Vos et al., 2010; Yang & Wu, 2012). Moreover, those researchers at competitive higher educational institutions reported mixed student satisfaction and no statistically significant increases in student success in a flipped classroom instructional environment (Crouch & Mazur, 2001; Demetry, 2010; Lage et al., 2000; Prakash, 2010; Strayer, 2012; Zappe et al., 2009).

To this date, there are no known studies regarding the flipped classroom instructional model in science courses intended for the non-science major at an open-enrollment college. While the academically average student may benefit from the flip, it is possible that student academic motivation may influence student achievement and satisfaction with the flipped classroom model (Lavender, 2005; Carini et al., 2006; Kettle, 2013; Kirschner et al., 2006). The data collected from this study helped determine if there was a difference in student achievement and satisfaction in a constructivist learning environment such as the flipped classroom compared to the traditional lecture environment. The data also provided information regarding the correlation between levels of academic motivation and pre-knowledge with student achievement in and satisfaction with the flipped classroom compared to the traditional lecture environment.

Definition of Key Terms

Active learning. Active learning occurs when students are engaged in their own learning (Felder, 2012).

Blended learning. Blended learning is a learning environment that combines an online and face-to-face learning environment. (Strayer, 2012).

Collaborative learning. Collaborative learning occurs when students work together to construct common meaning and knowledge (Felder, 2012).

Constructivism. As applied to education, constructivism is any teaching that is somewhat "student-centered", caring, inclusive, or based enquiry, discovery of any kind of active involvement from learners (Gordon, 2008; Koohang et al., 2009; Perkins, 1999; Wurst, Smarkola, & Gaffney, 2008).

e-Learning. E-learning involves an electronic media integrated into learning and is also referred to as online learning, distance learning, distance education (Koohang et al., 2009) .

Emerging technologies. Technologies that are contemporary and innovative are classified as emerging technologies (Felder, 2012; Koohang et al., 2009).

Face-to-Face environment. Face-to-face learning environment take place when students and teachers meet in person (Koohang et al., 2009).

Flipped Classroom. The flipped classroom is a pedagogical practice that reverses the traditional lecture and homework elements of a course (Bergman & Sams, 2012; Educause Learning Initiative, 2012).

Net Generation. The Net Generation are those individuals born from approximately 1980-1999 who show a marked increase in the use of and familiarity with technologies that allow them to communicate and learn (Prensky, 2001).

Non-science major. A non-science major student has no vocational interest in science and no specific science course required by his or her major (Pain, 2010).

Open-enrollment college: An open-enrollment college (also called open admissions) is a type of higher education institution where the only requirement for admission is a high school diploma or General Education Development (GED) certificate. (Penn College, 2012).

Passive learning. Passive learning occurs when students are disengaged in their own learning and rely heavily on the instructor's transfer of knowledge (Baeten et al., 2010; Vos et al., 2010; Sesen & Tarhan, 2010).

Podcast. A podcast is an episodic program delivered via the internet using an XML protocol called RSS. (Koohang et al., 2009).

Self-determination theory. The self-determination theory (SDT) is an empirically based theory that considers human motivation to fall into three broad categories: autonomous motivation, controlled motivation, and amotivation (Deci & Ryan, 2008a; Niemiec & Ryan, 2009; Vansteenkiste et al., 2009).

Student-centered learning. Student-centered learning occurs when learning and activities focus on the student or learner rather than the teacher (Gordon, 2008; Koohang et al., 2009; Perkins, 1999; Wurst, Smarkola, & Gaffney, 2008).

Vodcast. A vodcast is a blend of video and podcast that can be downloaded to a computer and is also referred to as vcast or videocast (Thompson, 2011).

Summary

The purpose of this quantitative study was to investigate the constructivist learning theory by comparing the flipped classroom learning environment with the traditional lecture learning environment. A comparison was made using posttest scores and student satisfaction with the flipped classroom learning environment, while considering the level of student academic motivation amongst non-science major students taking an elective science course at an open-enrollment college. Upon a thorough review of the literature, researchers provided little data regarding the implementation of the flipped classroom at higher educational institutions and no known studies were conducted in elective science courses at open-enrollment institutions. Further, there is a gap in the literature regarding whether pre-knowledge and level of academic motivation influence achievement and satisfaction in a constructivist learning environment such as the flipped classroom. By comparing student achievement in and satisfaction with the flipped and traditional classroom in a science elective course while controlling for the pre-knowledge and level of academic motivation should contribute to future applications of the flipped classroom learning environment.

Chapter 2: Literature Review

The flipped classroom learning environment provides a valid application for constructivist learning (Felder, 2012; Strayer, 2012). In order to investigate the constructivist learning theory as applied using the flipped classroom, a comparison of posttest scores was made from the flipped classroom learning environment and the traditional lecture learning environment. Further, student satisfaction within the flipped classroom learning environment was determined while considering the level of student academic motivation amongst non-science major students taking an elective science course at an open-enrollment college. The following literature review will provide the reader with an overview and evolution of the flipped classroom instructional model. Studies on the flipped classroom are limited, but those studies found in the literature will be discussed. Since the flipped classroom is grounded in the constructivist theory of learning, an overview of the constructivist theory is provided (Musallam, 2010; Strayer, 2012). Theoretical perspectives about constructivism and the limitations about the application of constructivism are outlined. Although the flipped classroom can be viewed through the lens of constructivism, one could also consider the flipped classroom a blended learning model (Felder, 2012; Lage et al., 2000; Musallam, 2010; Strayer, 2012). Technology has provided a vehicle by which the flipped classroom constructivist learning environment is delivered (Herreid & Schiller, 2013; Koohang et al., 2009). Finally, educational research is often dependent upon the individual learner in terms of his or her individual learning needs and styles and ultimately what methods are most conducive for optimal learning (De George-Walker & Keeffe, 2010; Heilesen, 2010; Herreid & Schiller, 2013; Lavasani & Ejei, 2011; Menchaca & Bekele, 2008; Pham, 2012). Student success and satisfaction in the constructivist and traditional learning environments will be discussed as well as how student motivation towards learning can affect success and satisfaction in a learning environment.

Documentation

This researcher conducted several methods to search for information, literature, and materials related to the topic of the flipped classroom. Since the flipped classroom pedagogical model is relatively new, few peer reviewed articles were readily available. Instead, the researcher focused on related theories that are foundational in the flipped classroom learning environment. The researcher began using GoogleScholar to locate articles on the flipped classroom and constructivism. From there, the researcher was able to determine where the articles or books were located. Online databases through Northcentral University (NCU) and Penn College (PCT) libraries were used. These databases included EBSCOhost PsycARTICLES, ERIC, ETS TestLink, SAGE Journals Online, Reference Online, and Research Methods, ScienceDirect, and Taylor & Francis Online. The Penn College Interlibrary Loan service was utilized when an article or book was not readily available. Keywords used, but not limited to, include: (a) constructivism, (b) self-determination theory, (c) motivation, (d) blended learning, (e) flipped classroom, (f) inverted classroom, (g) deep learning, (h) differentiated learning, (i) student success, (j) student satisfaction, (k) mastery learning, (l) motivation as covariate, and (m) quasi-experimental studies.

The Constructivist Learning Theory

Theories in the broadest definition stem from observations (Sternberg, 2008). According to Wacker (1998), a theory should have four basic criteria. Good theories have conceptual definitions and domain limitations, build relationships, and help make predictions (Wacker, 1998). Good theory is important as the theory aides in explaining and solving real-world problems (Wacker, 1998). Sternberg (2008) posited that one of the greatest challenges facing modern educational research is formulating and testing broad theories that can be applied across many disciplines.

Constructivism has emerged as a powerful theory for explaining how humans learn about the world around them and how new knowledge is formed (Felder, 2012; Gordon, 2008; Neo & Neo, 2009; Nie & Lau, 2010; Prakash, 2010). The theory of constructivism is that knowledge is not waiting to be discovered but rather it is constructed by humans by interaction with the world and with each other (Felder, 2012; Gordon, 2008; Neo & Neo, 2009; Nie & Lau, 2010; Prakash, 2010). Grounded in insights of theorists such as Vygotsky, Piaget, and Freire, constructivism has shifted the paradigm of understanding how knowledge is gained and internalized (Felder, 2012; Gordon, 2008). Vygotsky (1978) conceptualized a "zone of proximal development" which enabled researchers to realize that social and cultural contexts influence human development, learning, and knowing. Piaget (1972) posited that the path to gaining knowledge is equally or more important than the result of knowledge gained. Freire (1994) opined that knowledge is not something that individuals either possess or lack. Rather, knowledge is gained when individuals interact by exchanging ideas, articulate problems, and develop meaningful ways to make sense of the problems (Felder, 2012; Gordon, 2008; van Bommel, Kwakman, & Boshuizen, 2012; Vos et al., 2010; Yang & Wu, 2012). Further, this co-construction of knowledge leads to enhanced problem-solving and idea-making (Felder, 2012).

Learner collaboration, interaction, and engagement are foundational in the constructivist theory of learning (Felder, 2012; Prince & Felder, 2007; Prince & Felder, 2006; Neo & Neo, 2009; Nie & Lau, 2010; Sjober, 2007). Collaborative, interactive activities have been touted to be most effective at helping students reach a higher level of understanding (Carini et al., 2006; Menchaca & Bekele, 2008; Merrill, 2008; Neo & Neo, 2009; Nie & Lau, 2010; Sorden, 2011; Yang & Wu, 2012). Tynjala (1999) suggested that students in the constructivist learning environment acquire more diversified knowledge and are able to apply knowledge to real-life situations. The learner develops new ideas and alters existing ideas when interacting with content and collaborating with other learners and the instructor (Felder, 2012; Prince & Felder, 2007; Prince & Felder, 2006; Neo & Neo, 2009; Nie & Lau, 2010; Prakash, 2010; Sjober, 2007).

One of the more important core ideas that constructivists claim is that "knowledge is actively constructed by the learner, not passively received from the outside. Learning is something done by the learner, not something that is imposed on the learner" (Sjober, 2007, p. 3). Over the past years, educators have sought methods for applying the constructivist theory to the classroom (Sternberg, 2008). Researchers have developed a variety of instructional models to apply constructivist learning theory (Baeten et al., 2013; Co, 2010; Harun et al., 2012; Lasry, Mazur, & Watkins, 2008; Mazur, 2009; Nie & Lau, 2010; Prince & Felder, 2006; Vos et al., 2011; Wijnia, Loyens, & Derous, 2011; Yang & Wu, 2012). Constructivist learning environments such as problem-based learning (PBL), Peer Instruction (PI), inquiry-based learning through gaming, and most recently, the flipped classroom, have been applied in the classroom (Baeten et al., 2012; Baeten et al., 2013; Berrett, 2012; Co, 2010; Felder, 2012; Harun et al., 2012; Lasry et al., 2008; Mazur, 2009; Nie & Lau, 2010; Prince & Felder, 2006; Vos et al., 2011; Wijnia et al., 2011; Yang & Wu, 2012). The following sections of the literature review will provide the reader with an overview of problem-based learning (PBL), peer instruction (PI), educational gaming and digital storytelling, and the flipped classroom. These subcategories of constructivist learning all encourage active learning, but are implemented differently with the use of e-learning technology.

Problem-based learning. Problem-based learning is an inductive teaching method where students generally work in teams to solve ill-structured or open-ended problems (Araz & Sungar, 2007; Donnelley, 2012; Harun et al., 2012; Ruiz-Gallardo et al., 2011; Prince & Felder, 2006; Wijnia et al., 2011). Problem-based learning can be implemented in various disciplines of higher education where application of concepts is a goal (Harun et al., 2012; Ruiz-Gallardo et al., 2011; Prince & Felder, 2007). Such disciplines include health sciences, engineering, business, education, law, natural sciences, and computer-related fields (Harun et al., 2012; Ruiz-Gallardo et al., 2011; Prince & Felder, 2007). Students work together in the role of student and instructor while taking responsibility of the learning (Martin et al., 2008). Problem-based learning affords opportunities for self-directed learning through collaboration and problem-solving (Donnelley, 2012; Harun et al., 2012; Martin et al., 2008; Ruiz-Gallardo et al, 2011; Prince & Felder, 2006). Prince and Felder (2006) opined that learning environments influence students' motivation and self-regulated learning. However, problem-based learning was found to be the most difficult for teachers to implement and students were most resistant to this method of learning (Prince & Felder, 2006).

Problem-based learning is not a native learning process for students (Araz &

Sungar, 2007; Donnelley, 2012; Harun et al., 2012; Prince & Felder, 2006; Ruiz-Gallardo et al., 2011; Wijnia et al., 2011). The transition from traditional learning environments that are teacher-centered to student-centered learning environments is challenging for many students and instructors (Donnelley, 2012; Harun et al., 2012). Students express shock, frustration and resistance to PBL at the onset of implementation (Donnelley, 2012; Harun et al., 2012). Students have difficulties determining how to gain prior knowledge and determining what concepts are important (Donnelley, 2012; Harun et al., 2012; Ruiz-Gallardo et al., 2011). In a meta-reflection study over a seven year period of PBL implementation in an undergraduate chemical engineering course, Harun et al. (2012) concluded that motivation from the facilitator and a scaffolding approach to PBL implementation helped ease student frustration and resistance to the student-centered learning environment.

Motivating students to engage positively in the PBL environment is essential in PBL implementation and ensures that the "richness of PBL is achieved" (Harun et al., 2012, p. 234). The key is to move students to become mastery oriented learners as opposed to performance oriented learners (Martin et al., 2008). The facilitator can help with this transition by focusing students on the learning process and the importance of the task (Harun et al., 2012; Overbaugh & Nickel, 2011). The facilitator can implement several practices that can help motivate students in a PBL learning environment. These key practices are: 1) setting course goals, 2) students setting personal course goals, 3) capitalizing on students' interests and background knowledge, 4) use relevant materials, 5) model skills of independent learning, and 6) provide timely feedback (Harun et al., 2012; Overbaugh & Nickel, 2011).

Constructivist learning puts the student in the center of the learning process, therefore, the students' individual characteristics affect the learning (Baeten et al., 2013; Hill, 2013; Rastegar et al., 2010). Harun et al. (2012) opined that in order for PBL to be successful, students' level of motivation towards learning is essential. Learner autonomy is correlated with high quality motivation (Hill, 2013; Lavansani & Ejei, 2011; Martin et al., 2008; Vansteenkiste et al., 2009; Vos et al., 2010; Wijnia et al., 2011). Intrinsically motivated learners are mastery oriented and exhibit deep learning whereas extrinsically motivated learners are focused on performance outcomes and exhibit surface learning (Ryan & Deci, 2000). In order for PBL to be perceived as fun and beneficial, the facilitator must encourage students to develop intrinsic motivation and adopt mastery learning processes (Harun et al, 2012; Prince & Felder, 2006).

Good course design and learning activities are essential in maintaining and moving students toward intrinsic motivation (Harun et al., 2012; Lavansani & Ejei, 2011; Martin et al., 2008; Prince & Felder, 2006; Vansteenkiste et al., 2009; Vos et al., 2010; Wijnia et al., 2011). While Harun et al. (2012) determined that the facilitator has a major influence on whether the PBL environment promoted intrinsic motivation; other factors were found to be motivating and de-motivating in a PBL environment. Wijnia et al. (2011) found that the PBL students scored higher on competence but that there was no significant difference in autonomous motivation between the PBL and traditional lecture groups. Active learning in the form of collaborative activities was perceived as motivating (Harun et al., 2012; Lavansani & Ejei, 2011; Martin et al., 2008; Prince & Felder, 2006; Vansteenkiste et al., 2009; Vos et al., 2010; Wijnia et al., 2011). However, controlling aspects of both PBL and the traditional lecture environments, such as mandatory attendance and uncertainty in instructional expectations were found to be detrimental to student motivation (Wijnia et al., 2011). Further, researchers found that de-motivating aspects stemmed from a lack of content knowledge necessary to engage in the PBL environment (Araz & Sungar, 2007; Donnelley, 2012; Harun et al., 2012; Kirschner et al., 2006; Prince & Felder, 2006; Ruiz-Gallardo et al., 2011; van Bommel et al., 2012). Implementation of e-learning technology could leverage the knowledge required for students to take full advantage of PBL (Donnelley, 2012; Koohang et al., 2009; Neo & Neo, 2009; Roberts, 2010; Sutton-Brady, Scott, Taylor, Carabetta, & Clark, 2009).

Harmonizing technology with the PBL environment is challenging for many instructors in higher education (Donnelley, 2010). Many faculty view technology as a necessity in teaching and learning, but few faculty realize the affordances of e-learning technologies in a PBL environment (Donnelley, 2010; Neo & Neo, 2009; Nie et al., 2010). There are several technology tools that enhance success in the utilization of technology in a PBL environment (Donnelley, 2010). Podcasting was found to be one of the most useful elearning tools to enhance the PBL environment (Donnelley, 2010; Heilesen, 2010; Musallam, 2010; Neo & Neo, 2009; Nie et al., 2010). Podcasts were found to be beneficial due to the replacement of the typed word with voice recordings and visuals that provided differentiated delivery of content (Donnelley, 2010; Heilesen, 2010; Neo & Neo, 2009; Nie et al., 2010). Donnelley (2010) suggested that more research should be conducted to provide a basis for choosing specific technologies and how to use these technologies to achieve specific outcomes.

Peer Instruction. Peer Instruction (PI) is a student-centered learning environment where information transfer occurs outside the classroom so that active learning can take place in the classroom (Mazur, 2009). Schell (2012) suggested that PI encouraged students to engage with subject matter before class so that F2F class time can be spent uncovering misconceptions and confusion about the concepts. Like PBL, PI can be implemented using various methods (Prince & Felder, 2006; Mazur, 2009). One method is to engage students with subject manner through textbook readings prior to the F2F class in preparation for collaborative questions and discussion. Peer Instruction utilizes a modified traditional F2F lecture to include questions that students answer as part of a group (Crouch & Mazur, 2001; Mazur, 2009; Mora, 2010; Moss & Crowley, 2011; Schell, 2012). As an incentive to complete the textbook readings, a variety of methods which included reading quizzes, short summaries, and free response to questions were employed (Crouch & Mazur, 2001; Mazur, 2009; Mora, 2010; Moss & Crowley, 2011; Schell, 2012).

Student test scores increased significantly in the PI environment compared to the traditional lecture learning environment (Crouch & Mazur, 2001; Mazur, 2009; Mora, 2010). However, when implemented in a science course, non-science students were more dissatisfied with PI than students majoring in a science discipline (Crouch & Mazur, 2001; Mazur, 2009). Researchers found that PI increased retention in science courses notorious for high attrition rates (Lasry et al., 2008). A subsequent modification of PI using personal response systems (PRS) resulted in e-learning technologies which provided methods for assessing pre-class knowledge acquisition (Mazur, 2009; Schell, 2012).

With advances in e-learning technologies PRSs or "clickers" were used to assess the extent of knowledge acquisition outside of class (Mazur, 2009; Moss & Crowley, 2011; Schell, 2012). At the beginning of class, students were given the opportunity to clarify misconceptions and formulate new ideas and skills in a discipline. In addition to using PRSs, Mazur (2009) developed ConcepTests which consisted of prepared questions that are posed to students to assess learning outside of class. Students were given the opportunity to reflect on the question, provide an answer using the PRS, discuss their answers with peers, and again provide an answer using the PRS (Lasry et al., 2008; Mazur, 2009; Mora, 2010; Moss & Crowley, 2011; Schell, 2012).. This format of self-reflection and clarification is enhanced with the use of technology and provides a means for assessing gained learning outside of class (Mazur, 2009). Using data obtained from PI colleagues worldwide, Mazur (2009) determined that learning gains nearly tripled and problem-solving skills improved with this learner-centered approach.

While Mazur's research concentrated on PI implementation at competitive four year institutions, the effectiveness of PI at a two-year college was unclear (Lasry et al., 2008). Lasry et al. (2008) found that the PI group did not score statistically higher than the traditional group on the final exam. However, Lasry et al. (2008) did find that retention in the PI group was significantly higher than the traditional lecture group at both the two-year college and competitive university. Students with more scientific reasoning skills on the pretest had larger increases in posttest scores (Felder, 2012; Lasry et al., 2008; Kettle, 2013; Kirschner et al., 2006). These findings support the idea that new knowledge is best gained by constructing ideas from prior experiences (Gordon, 2008).

Researchers wanted to extend the use of PRSs beyond the college physics classroom to determine if the integration of technology and PI was affective. A constructivist learning environment like PI may not be appropriate for all settings and students (Mora, 2010; Moss & Crowley, 2011). Non-science students found PI to be enjoyable and less threatening in both a non-classroom setting and in an introductory science class intended for non-science majors (Mora, 2010; Moss & Crowley, 2011). Perceived learning for non-science students was high, but the actual assessment of knowledge gained was minimal (Mora, 2010; Moss & Crowley, 2011). However, learning gains were most significant for those non-science students with lower prior knowledge (Mora, 2010). Even though gains in learning were not significantly higher using PI, non-science students reported that PI more enjoyable than the traditional lecture and instructors found PI easily implemented (Lasry et al., 2008; Mora, 2010; Moss & Crowley, 2011). Mora (2010) concluded that active learning instruction techniques are "beneficial to students enrolled in introductory science classes" (p. 292).

Educational games and digital storytelling. Traditional lecture learning environments deliver content from the instructor to the learner where the learning is considered passive (Nie & Lau, 2010; Overbaugh & Nickel, 2011). Problem-solving and critical thinking skills seldom evolve in the teacher-centered environment (Overbaugh & Nickel, 2011; Prince & Felder, 2006; Vos et al., 2011; Yang & Wu, 2012). With the availability of emerging technologies, the ability for students to learn collaboratively and through personal learning experiences has increased dramatically (Koohang et al., 2009; Martin et al., 2008; Overbaugh & Nickel, 2011; Vos et al., 2011; Yang & Wu, 2012).

Educational games and digital storytelling (DST) have emerged as a practical application of the constructivist learning environment (Vos et al., 2011; Yang & Wu, 2012). Not only do students actively participate in the learning process, students gain 21st century skills such as team work, information literacy, and collaboration through technology (Koohang et al., 2009; Martin et al., 2008; Overbaugh & Nickel, 2011; Vos et al., 2011; Yang & Wu, 2012). Further, educational games and DST can enhance learning by providing alternate means of knowledge acquisition, increase critical thinking skills, motivation, and information literacy (Vos et al., 2011; Yang & Wu, 2012).

Methods for practical applications of constructivist learning have been difficult to implement (Koohang et al., 2009). Learning is enhanced when a student plays an active role in the making of a game or story (Neo & Neo, 2010; Vos et al., 2011; Yang & Wu, 2012). Researchers found that the game-playing and DST positively influenced academic achievement, critical thinking, and learning motivation compared to the traditional learning environment (Araz & Sungar, 2010; Neo & Neo, 2009; Nie & Lau, 2010; Overbaugh & Nickel, 2011; Vos et al., 2011; Yang & Wu, 2012). Further, the collaborative approach to problem-solving, creativity, and goal-orientation fostered self-efficacy and satisfaction with the learning experience to a greater extent than the traditional lecture learning environment (Araz & Sungar, 2010; Neo & Neo, 2009; Nie & Lau, 2010; Overbaugh & Nickel, 2011; Yang & Wu, 2012). Researchers provided evidence for a practical application of constructivism through the use of technology (Vos et al., 2011; Yang & Wu, 2012). However, the implementation of digital storytelling and game-making might be difficult for students and faculty who have little digital media experience (Yang & Wu, 2012). Multimedia such as pod- and vodcasts are used regularly by many students and instructors and may be an easier application to promote constructivism (Brunsell & Horejsi, 2011; De George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Nie et al., 2010; Sutton-Brady et al., 2009).

The flipped classroom. The flipped classroom inverts the expectations of the traditional classroom (Berrett, 2012; Herreid & Schiller, 2013). Students gather prior knowledge outside of the classroom by reading, viewing vodcasts, or listening to podcasts (Berrett, 2012; Herreid & Schiller, 2013). In class, students do what is typically considered homework. Students solve problems and interact with classmates and the instructor. Problem-based learning, peer instruction, educational gaming, and digital storytelling are all applications of the flipped classroom (Berrett, 2012; Felder, 2012; Herreid & Schiller, 2013). But, generally, most flipped classrooms utilize lecture- or classroom-capture technologies to deliver "lectures" to the learner as homework in the form of pod- or vodcasts (Bergmann & Sams, 2012; Educause Learning Initiative, 2012; Herreid & Schiller, 2013; Houston & Lin, 2011; Lage et al., 2000; Strayer, 2012; Thompson, 2011; Zappe et al., 2009).

The idea of the flipped classroom stemmed from students needing help with homework problems and problem-solving and teachers needing more time to interact with the student (Bergmann & Sams, 2012; Herreid & Schiller, 2013; Lage et al., 2000; Mazur, 2009). Both Lage et al. (2000) and Bergmann and Sams (2012) questioned when students needed the instructor the most. Students need the teacher most when he or she is trying to solve a problem, think critically, or construct new ideas (Bergmann & Sams, 2012; Educause Learning Initiative, 2012; Houston & Lin, 2011; Lage et al., 2000; Strayer, 2012; Thompson, 2011; Zappe et al., 2009). This answer led to the teaching strategy that is now called the flipped or inverted classroom. Students gain low-level knowledge outside the classroom via technology and utilize higher-level thinking skills in the classroom with classmates and the teacher (Bergmann & Sams, 2012; Herreid &

Schiller, 2013; Strayer, 2012).

The term for the inverted classroom learning environment was coined in the early 2000s (Herreid & Schiller, 2013). Lage et al. (2000) were amongst the first researchers that explored the idea of delivering lecture content outside the class via multimedia to increase collaboration and cooperation during F2F time. To accomplish this goal, the Lage et al. (2000) created an environment where multimedia was integrated into the course in order to increase interactive F2F time. Students and staff in five sections of a microeconomics class at a competitive university were surveyed to determine perceptions of the inverted classroom. Students preferred the inverted classroom to the traditional lecture classroom and would prefer taking future courses in the same format (Armaral & Shank, 2010; Crouch & Mazur, 2001; Lage et al., 2000; Mazur, 2009). Faculty in the study suggested that using this methodology may attract female students who prefer a more collaborative learning environment (Lage et al., 2000), and that the instructor had more flexibility in the F2F classroom while still maintaining control over content coverage and delivery (Pham, 2012; Strayer, 2012). Multimedia provided a practical method for content delivery and knowledge acquisition prior to constructivist learning (Aramaral & Shank, 2010; Herreid & Schiller, 2013; Koohang et al., 2009; Lage et al., 2000; Mazur, 2009; Nie et al., 2010; Sutton-Brady et al., 2009; Taylor & Parsons, 2011; Veenema & Gardner, 1996).

Although teachers at the K-12 setting were beginning to apply the inverted classroom in the mid-2000s, a lack of empirical evidence prevailed (Aramaral & Shank, 2010; Bergmann & Sams, 2012; Herreid & Schiller, 2013; Musallam, 2010; Zappe et al., 2009). Faculty at higher educational institutions provided some data regarding student satisfaction in engineering courses. Zappe et al. (2009) investigated the concept of the flipped classroom in a qualitative pilot study implemented in an undergraduate architectural engineering class at a competitive university.

Active learning strategies should increase students' comfort at solving problems and increase his or her understanding of the concepts (Herreid & Schiller, 2013; Kettle, 2013; Prakash, 2010; Yang & Wu, 2012; Zappe et al., 2009). Zappe et al. gathered student comments utilizing an end-of-class minute paper about the flipped classroom and a survey was created from information gathered from the minute paper. The majority of students watched the videos, but preferred the videos in shorter durations (Bergmann & Sams, 2012; Koohang et al., 2009; Neo & Neo, 2009; Zappe et al., 2009). The majority of students felt that the flipped format was helpful, but did not want every class to be held in this format (Lage et al., 2000; Strayer, 2012; Zappe et al., 2009). While a constructivist learning environment was applied through the use of technology, Zappe et al. (2009) did not find that student satisfaction and academic achievement increased significantly. Individual student characteristics like motivation may be correlated with student preference for the flipped classroom (Baeten et al., 2010; Baeten et al., 2013; Kettle, 2013; Neo & Neo, 2009; Ning & Downing, 2012; Prakash, 2010; Vansteenkiste et al., 2009).

Realizing the potential benefits of integrating technology into the classroom, science teachers began conducting research in advanced placement (AP) chemistry courses at the K-12 level to determine if this instructional model increased test scores. Musallam (2010) conducted an experimental study in an advanced placement (AP) high school chemistry class where cognitive load theory was examined in a flipped classroom learning environment. Prior to enrollment in this AP chemistry, students were required to earn an A in an introductory chemistry course. Two groups from this class were formed randomly where one group viewed a pre-recorded screencast (experimental) and the other group did not (control). All students were given a pre- and posttest on chemical equilibrium and both groups received the same 50-minute instructional lecture. Posttest scores showed a reduction in intrinsic load in the pre-recorded screencast group (Musallam, 2010). Students who were exposed to a pre-recorded screencast were more successful than students who did not view a screencast prior to a lesson (Acat & Donmez, 2009; Musallam, 2010; Yang & Wu, 2012). The experimental group received more instruction on the chemical equilibrium and this extra instruction may have contributed to an increase in the experimental group's posttest scores (Musallam, 2010).

While the number of studies with the flipped or inverted classroom increased, researchers continued to question whether students were more satisfied with the learning process in the flipped classroom environment at the college level (Berrett, 2012). In a mixed-methods study, Strayer (2012) compared the inverted classroom environment to the traditional lecture environment with respect to activity theory and learning environments research. The participants included students in two sections of an introductory statistics class and were enrolled in different majors across the university. Data were collected using the CUCEI that measured both student learning environment preferences and learning environment experiences (Fraser & Treagust, 1986; Fraser et al., 1986; Strayer, 2012).

Students were less satisfied with how the structure of the flipped classroom oriented the student to the learning tasks in the course (Berrett, 2012; Lage et al., 2000;

Strayer, 2012; Zappe et al., 2009). The constructivist learning environment did not significantly increase student satisfaction with the course (Lage et al., 2000; Strayer, 2012; Zappe et al., 2009). Strayer (2012) utilized a computer-aided homework system (ALEXS) to provide students with "pre-class" information. Since this was not in the lecture format of a vod- or podcast, students may have been lacking the fundamental knowledge to perform the in-class activities (De George-Walker & Keeffe, 2010; Heilesen, 2010; Kirschner et al., 2006; Nie et al., 2010; Musallam, 2010; Sutton-Brady et al., 2009; Zappe et al., 2009). Students may have been more satisfied with the flipped classroom if fundamental concepts were delivered similar to a lecture, but via technology (De George-Walker & Keeffe, 2010; Heilesen, 2010; Koohang et al., 2009; Nie et al., 2010; Niemiec & Ryan, 2009; Musallam, 2010; Sutton-Brady et al., 2009; Zappe et al., 2009) . Strayer (2012) suggested that future research may include investigating the flipped classroom in other courses where the course material may lend itself to being taught using this methodology.

Limitations to constructivist learning. Constructivism has emerged as a powerful model for explaining how humans learn about the world around them and how new knowledge is formed (Felder, 2012; Gordon, 2008). Constructivist learning places the student in the center of the learning process and makes the student responsible for his or her own learning (Felder, 2012; Kirschner et al., 2006; van Bommel et al., 2012). Student-centered learners must be self-directed, motivated to learn, and have self-efficacy in the learning process (Felder, 2012; Harun et al., 2012; Kirschner et al., 2006; Marchand & Gutierrez, 2012; Nie & Lau, 2010; Ning & Downing, 2012; van Bommel et al., 2012; Wilde & Urhahne, 2008). Kirschner et al. (2006) argued that self-directed learning is too demanding for students and students are resistant to this method of instruction. Further, not all students are alike and student-centered, self-directed learning is not equally beneficial to all students (van Bommel et al., 2012; Wilde & Urhahne, 2008). Many students prefer the passive learning environment where the knowledge is received not constructed and assimilated (Berrett, 2012; van Bommel et al., 2012).

Factors that impede or detract from the constructivist learning experience come from the individual learner (Kirschner et al., 2006; van Bommel et al., 2012; Wilde & Urhahne, 2008). Limitations in the constructivist theory stem from the inability of some learners to draw from experiences simply because he or she lacks prior knowledge in a subject area (Kirschner et al., 2006; van Bommel et al., 2012). Kirschner et al. (2006) argued that constructivist learning is not effective when guidance during instruction is minimal. It is difficult for any learner to construct his or her ideas when there is no reference to working memory (Kirschner et al., 2006; van Bommel et al., 2012). In fact, Kirschner et al. (2006) suggested that constructivist learning is detrimental to novice learners who lack prior knowledge.

Minimally guided instructional approaches are intuitively appealing for most instructors, but most learners require high prior knowledge and academic motivation to be successful and satisfied in this learning environment (Demetry, 2010; Kirschner et al., 2006; Nie et al., 2010; van Bommel et al., 2012). In addition, constructivist learning activities require more time to prepare and implement than the traditional lecture learning environment (Berrett, 2012; Felder, 2012; Kirschner et al., 2006; Perkins, 1999; Prince & Felder, 2006; van Bommel et al., 2012). Further, instructors who teach in a constructivist learning environment have to be “good at answering students' questions on the spot”

(Berrett, 2012, p. 5). Many instructors are pressured to cover a long list of learning objectives in order to prepare students for future courses or high-stakes assessments (Koohang et al., 2009). As a result, many instructors choose not to implement constructivist learning environments (Felder, 2012; Kirschner et al., 2006; Perkins, 1999; Prince & Felder, 2006; van Bommel et al., 2012).

Constructivism has been difficult to apply in educational settings under the traditional model of the teacher-centered learning environment (Koohang et al., 2009; Vos et al., 2010; Yang & Wu, 2012). There are limitations that exist in the constructivist theory that affect its implementation (van Bommel et al., 2012). "The student plays a central role in mediating and controlling learning" (Koohang et al., 2009, p. 93). Moderate constructivism employs social, active, and self-regulated learning in a learning environment with an instructor present (Wilde & Urhahne, 2008). In the moderated constructivist learning environment, a balance between constructivist and instructive pieces are provided by the instructor (Wilde & Urhahne, 2008). The application of moderate constructivism is more easily accomplished in areas of science education (Wilde & Urhahne, 2008). However, with time constraints ever present in a F2F classroom, moderate constructivism is difficult to implement (Koohang et al., 2009). Educational technology can aid in the delivery of instructive elements required for a moderate constructivist learning environment (Koohang et al., 2009).

Technology can be used to provide a student with prior knowledge so that constructivism can be implemented (Donnelley, 2012; Koohang et al., 2009; Musallam, 2010; Vos et al., 2010; Yang & Wu, 2012). To that end, educators have begun using technology as a means to provide prior knowledge to students so that a learner-centered constructivist environment can be applied (Demetry, 2010; Lage et al., 2000; Zappe et al., 2009). Instructors who implement the flipped classroom utilize technology to provide students with prior knowledge in order to apply a constructivist learning environment (Felder, 2012). The flipped classroom learning environment is considered a blended constructivist learning environment because of the infusion of technology that moves the student to the center of the learning process (Felder, 2012; Kim & Bonk, 2005; Strayer, 2012)

Blended Learning

Integration of technology into the constructivist learning environment could fall within the definition of blended learning (Baeten et al., 2010; De George-Walker & Keeffe, 2010; Donnelley, 2010). The overlying definition of substituting electronic activity for classroom time has become the broadest and most applicable definition of blended learning (Albrecht, 2006; Baeten et al., 2010; De George-Walker & Keeffe, 2010; Donnelley, 2010). Kim and Bonk (2005) predicted that blended learning would have a dramatic increase resulting from all college courses having some Web component. The external benefits for incorporating technology into the constructivist learning environment are important (Donnelley, 2010; Koohang et al., 2009; Lopez-Perez et al., 2011; Pham, 2012). These benefits include convenience for the learner and instructor (anytime, anywhere learning) (Prensky, 2001), enable problem-solving (Neo & Neo, 2009), increase self-esteem and motivation (Neo & Neo, 2009), the ability to assess in a variety of ways (Koohang et al., 2009), lower withdrawal rates (Lasry et al., 2008), greater success (Albrecht, 2006; Neo & Neo, 2009), and an increase in student-teacher, student-student interaction in the classroom (Albrecht, 2006; Bates & Galloway, 2012;

Bergmann & Sams, 2012).

Multimedia can be used to enhance interaction, exploration, relevancy, instruction, and authentic assessment (Heilesen, 2010; Nie et al., 2010; Sutton-Brady et al., 2009; Taylor & Parsons, 2011; Veenema & Gardner, 1996; Vos et al., 2010; Yang & Wu, 2012) which in turn can promote a constructivist learning environment (Koohang et al., 2009; Vos et al., 2010; Yang & Wu, 2012). As a result, students are more motivated to learn, apply knowledge, and take ownership of their learning (Koohang et al, 2009; Lopez-Perez et al., 2011; Taylor & Parsons, 2011; Vos et al., 2010; Yang & Wu, 2012).

Effectiveness of blended learning. With the proliferation and increased integration of new educational technologies, it is possible to make improvements teaching and learning in higher education (Koohang et al., 2009; Musallam, 2010; Vos et al., 2010; Yang & Wu, 2012). Researchers reported an increase in student success when blended learning environments are implemented in higher education courses (Armaral & Shank, 2010; Heilesen, 2010; Kiriakidis et al., 2011). While the effectiveness of a learning environment is often examined in terms of course grades or exam scores, student perceptions and satisfaction with the learning environment should also be considered (Giannousi, Vernadakis, Derri, Michalopoulos, & Kioumourtzoglou, 2009).

In addition to determining whether blended learning increases student success, researchers posited that individual characteristics like motivation, satisfaction, and perceived utility are correlated with student success in a blended learning environment (Acat & Donmez, 2009; Araz & Sungur, 2007; Baeten et al., 2010; Brunsell & Horejsi, 2011; Harun et al., 2012; Lopez-Perez et al., 2011; Neo & Neo, 2009; Nie et al., 2010; Roberts, 2010). Blended learning had a positive effect on student success and retention, and that individual characteristics were correlated with success, which in turn, explained why students were more successful in a blended learning environment (Acat & Donmez, 2009; Armaral & Shank, 2010; Araz & Sungur, 2007; Baeten et al., 2010; Baeten et al., 2013; Brunsell & Horejsi, 2011; Harun et al., 2012; Lopez-Perez et al., 2011; Neo & Neo, 2009; Nie & Lau, 2010; Roberts, 2010; Vos et al., 2010; Yang & Wu, 2012).

Researchers began to investigate blended learning in notoriously difficult subjects such as chemistry. Armaral and Shank (2010) moved an introductory chemistry course to the blended learning environment by creating a class guide that would facilitate student engagement inside and outside of the classroom. From the resulting data, Armaral and Shank (2010) found an increase in retention and final grades in the blended class. Students listed online quizzes and PRSs as the most useful tools in knowledge acquisition and comprehension (Armaral & Shank, 2010; Crouch & Mazur, 2001; Lasry et al., 2008; Mazur, 2009; Moss & Crowley, 2011). Students were initially dissatisfied with this new pedagogical approach (Armaral & Shank, 2010; Mazur, 2009; Strayer, 2012). However, Armaral and Shank (2010) noted that upon earning higher exam scores students became more satisfied with the blended learning environment. Further, students expressed disappointment when blended learning was not used in subsequent courses (Armaral & Shank, 2010; Lopez-Perez et al., 2011).

Similarly, Lopez-Perez et al. (2011) found that blended learning significantly increased student exam scores in a college business course. Further, Lopez-Perez et al., (2011) found that students considered blended learning useful to understanding the content, were satisfied with the experience, and were more motivated to study the subject. The F2F component of blended learning was perceived as a greater utility to students learning the material and promoted satisfaction and motivation with the experience compared to the online learning portion (Lopez-Perez et al., 2011).

In summary, online learning compliments the F2F learning environment in terms of student success, perceived utility, satisfaction, and motivation (Acat & Donmez, 2009; Armaral & Shank, 2010; Araz & Sungur, 2007; Baeten et al., 2010; Baeten et al., 2013; Brunsell & Horejsi, 2011; Harun et al., 2012; Lopez-Perez et al., 2011; Neo & Neo, 2009; Nie & Lau, 2010; Roberts, 2010; Vos et al., 2010; Yang & Wu, 2012). Both online and F2F learning "support and enhance the benefits derived from the other" (Lopez-Perez et al., 2011, p. 822). Blended learning allows for constructivist learning while considering individual student learning characteristics and perceived satisfaction, utility, and motivation (Acat & Donmez, 2009; Armaral & Shank, 2010; Araz & Sungur, 2007; Baeten et al., 2010; Baeten et al., 2013; Brunsell & Horejsi, 2011; Harun et al., 2012; Lopez-Perez et al., 2011; Neo & Neo, 2009; Nie & Lau, 2010; Roberts, 2010; Vos et al., 2010; Yang & Wu, 2012). Meeting the needs of all learners using differentiated instruction has been difficult to implement in the traditional classroom (Bloom, 1984). However, differentiated learning can be accomplished in the blended learning environment (De George-Walker & Keeffe, 2010; Pham, 2012).

Differentiated learning with technology. Collaborative, interactive activities have been touted to be most effective at helping students reach a higher level of understanding (Carini et al., 2006; Menchaca & Bekele, 2008; Merrill, 2008; Nie & Lau, 2010; Pham, 2012; Taylor & Parsons, 2011; Yang & Wu, 2012). Student diversity and academic readiness have become factors that affect student learning, and as a result, differentiated instruction is becoming critical in higher education (Pham, 2012).

Differentiated learning is not simply matching teaching styles with student learning styles and preferences (Pham, 2012). Rather, differentiated instruction emphasizes learner readiness as the focal point of instruction, and provides students with opportunities to take and construct the information in a preferred manner (De George-Walker & Keeffe, 2012; Pham, 2012).

The most effective forms of differentiated instruction are one-on-one tutoring and mastery learning (Bergmann & Sams, 2012; Bloom, 1984; De George-Walker & Keeffe, 2012). Bloom (1984) determined that one-on-one tutoring (student-teacher interaction) had the most profound effect on learning. Using standard deviations (sigma) from the control (conventional), Bloom (1984) found that mastery learning produced one standard deviation higher than the control and one-on-one tutoring produced two standard deviations higher than the control. The one-on-one tutoring process demonstrated that most students do have the potential to reach a high level of learning, but one-on-one tutoring is impractical and costly in the traditional classroom setting (Bloom, 1984). Practical limitations such as class size and differentiated student learning impede the one-on-one tutoring that Bloom (1984) found to be most beneficial. Blended learning provides the instructor with more opportunities to work with students individually, differentiate the instruction, and motivate each student towards learning (Bergmann & Sams, 2012; De George-Walker & Keeffe, 2012; Pham, 2012).

Not all students learn similarly (Bloom, 1984; De George-Walker & Keeffe, 2012; Pham, 2012). A "one-size-fits-all" approach is ineffective at meeting the individual student's needs (Bloom, 1984; Pham, 2012). Differentiated instruction can be implemented using new technologies in a blended learning environment (De George-

Walker & Keeffe, 2012; Sutton-Brady et al., 2009; Pham, 2012). Individual student differences like motivation are more easily addressed using technology (Bergmann & Sams, 2012; De George-Walker & Keeffe, 2012; Lopez-Perez et al., 2011; Menchaca and Bekele, 2008; Pham, 2012). Multiple technology learning tools are important for success and these tools that assisted with discussion and collaboration were found to be the most valuable (Armaral & Shank, 2010; Bergmann & Sams, 2012; Brunsell & Horejsi, 2011; De George-Walker & Keeffe, 2012; Lopez-Perez et al., 2011; Sutton-Brady et al., 2009; Menchaca and Bekele, 2008; Pham, 2012). The utilization of multiple technology tools in a blended learning environment meets the needs of individual learning intelligences and support an autonomous, constructivist learning environment (Armaral & Shank, 2010; Bergmann & Sams, 2012; De George-Walker & Keeffe, 2012; Donnelley, 2010; Heilesen, 2010; Lopez-Perez et al., 2011; Sutton-Brady et al., 2009; Menchaca and Bekele, 2008; Pham, 2012) .

Higher education instructors are encouraged to find more effective methods to differentiate the learning while meeting institutional goals for efficiency and accountability (De George-Walker & Keeffe, 2010). Blended learning could be the solution (Armaral & Shank, 2010; De George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Lopez-Perez et al., 2011; Menchaca and Bekele, 2008; Sutton-Brady et al., 2009; Pham, 2012). However, the best practices for the design and implementation of blended learning are not clear (De George-Walker & Keeffe, 2010; Donnelley, 2010). Blended learning is not about the technologies, but rather the pedagogy and the learning (De George-Walker & Keeffe, 2010). To that end, the learning outcomes and student characteristics should be considered when choosing technology to integrate the on- and off-campus learning experiences (De George-Walker & Keeffe, 2010).

Self-directed, differentiated learning afforded all students opportunities to become independent learners (De George-Walker & Keeffe, 2010). Recorded lectures using podcasting was found to be the most useful technology tool for student learning in both the F2F and online environments (Armaral & Shank, 2010; Bergmann & Sams, 2012; Brunsell & Horejsi, 2011; De George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Lopez-Perez et al., 2011; Menchaca and Bekele, 2008; Musallam, 2010; Nie et al., 2010; Schell, 2012; Pham, 2012; Sutton-Brady et al., 2009; Toppo, 2011). Integration of podcasts and vodcasts to deliver content knowledge is an effective method for the implementation of a blended learning environment (Armaral & Shank, 2010; Bergmann & Sams, 2012; De George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Lopez-Perez et al., 2011; Menchaca and Bekele, 2008; Musallam, 2010; Nie et al., 2010; Schell, 2012; Pham, 2012; Sutton-Brady et al., 2009; Toppo, 2011).

Podcasts and Vodcasts. Podcasts and vodcasts have been found to be among the most effective emerging technologies in education (Armaral & Shank, 2010; Bergmann & Sams, 2012; Brunsell & Horejsi, 2011; De George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Lopez-Perez et al., 2011; Menchaca and Bekele, 2008; Musallam, 2010; Neo & Neo, 2009; Nie & Lau, 2010; Schell, 2012; Pham, 2012; Sutton-Brady et al., 2009; Toppo, 2011; Zappe et al., 2009). Morales and Moses (2006) opined that "podcasting has revolutionized education and particularly higher education by enabling up-to-date content, addressing multiple intelligences, and allowing for the anytime/anywhere delivery of instructional content" (p. 1). Podcasts and vodcasts are pedagogically beneficial in areas of lecture, tutoring, and remediation (Armaral & Shank, 2010; Bergmann & Sams, 2012; De George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Lopez-Perez et al., 2011; Menchaca and Bekele, 2008; Morales & Moses, 2006; Musallam, 2010; Nie et al., 2010; Schell, 2012; Pham, 2012; Sutton-Brady et al., 2009; Toppo, 2011; Zappe et al., 2009). Recorded lectures provided methods to catch up on, review, or re-learn concepts he or she may have missed in the F2F lecture (Bergmann & Sams, 2012; George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Strayer, 2012). On an individual basis, students take the time needed to interact with a podcast or vodcast. Many students pause, rewind, or fast forward through the pod- or vodcast in order to learn the material at their own pace, and as a result differentiated learning is implemented (George-Walker & Keeffe, 2010; Donnelley, 2010; Heilesen, 2010; Morales & Moses, 2006).

Podcasts and vodcasts are effective tools to deliver content outside of class (De George-Walker & Keeffe, 2010; Heilesen, 2010; Nie et al., 2010). Many instructors ask students to read material prior class meetings. For some students, written information has little meaning until it is heard (Brunsell & Horejsi, 2011; Heilesen, 2010; Morales & Moses, 2006; Pham, 2012). Providing a pod- or vodcast in conjunction with text readings allows a student to interact with the content in a way that is best for them (Bergmann & Sams, 2012; De George-Walker & Keeffe, 2010; Heilesen, 2010; Nie et al., 2010; Pham, 2012). In addition to meeting the needs of individual students, pod- and vodcasts personalize the content delivery (Pham, 2012). Flexibility and mobility with the content is also possible and minimal adaptation is required due to the idea that content can be 'designed once, delivered many times' (Nie et al., 2010). The podcasted lecture allowed more class time for discussion, clarification, and exemplification of concepts

(Bergmann & Sams, 2012; Musallam, 2010; Heilsen, 2010). Heilesen (2010) suggested that more studies should be conducted in academic institutions where the traditional lecture is the dominant learning environment. Pod- and vodcasts are effective pedagogical tools and when used in conjunction with a collaborative, engaging F2F learning environment, a "perfect storm" of technology and constructivism produces the flipped classroom instructional model (Bergmann & Sams, 2012; Musallam, 2010; Heilsen, 2010).

Self-Determination Theory

Motivation research focuses on the “processes and conditions that affect competence, performance, healthy development, and vitality of our human endeavors (Deci & Ryan, 2008a, p. 14). Motivation is differentiated by the self-determination theory (Deci & Ryan, 2008a). The self-determination theory (SDT) is an empirically based theory that considers human motivation to fall into three broad categories: autonomous motivation, controlled motivation, and amotivation (Hill, 2013; Niemiec & Ryan, 2009; Deci & Ryan, 2008a). Deci and Ryan (2008a) reported that levels of motivation can predict outcomes in a person’s performance, relationships, and general well-being.

According to Ryan and Deci (2000), the SDT is an "approach to human motivation and personality that uses traditional empirical methods while employing an organismic metatheory that highlights the importance of humans' evolved inner resources for personal development and behavioral self-regulation" (p. 68). The self-determination theory proposes that humans have a basic psychological need for autonomy, competence, and relatedness (Deci & Ryan, 1985; Ryan & Deci, 2000). The self-determination theory also determines the degree to which these needs are satisfied through a social environment and the facilitation of an individuals' internalization of the content (Ryan & Deci, 2000). Ryan and Deci (2000) suggested that autonomous, social environments catalyze greater intrinsic motivation, curiosity, and desire for challenge" (p. 71).

In a classroom setting, the interpersonal climate can either be autonomy supportive or controlling (Deci & Ryan, 2008a). The orientation of the teacher- either autonomy supportive or controlling- dictates the interpersonal classroom climate (Baeten et al., 2010; Baeten et al., 2013; Deci & Ryan, 2008a). Learners become more intrinsically motivated towards learning in an autonomous learning environment (Deci & Ryan, 1985; Deci & Ryan, 2008a; Harun et al., 2012; Hill, 2013; Niemiec & Ryan, 2009) and the level of motivation towards learning may affect student achievement in and satisfaction with a constructivist learning environment (Vansteenkiste et al., 2009). This theory indicates that learning environments that support autonomy and promote competence and relatedness such as a constructivist environment like the flipped classroom should foster inherent student growth and motivation towards learning (Ryan & Deci, 2000).

Levels of motivation. Ryan and Deci (2000) postulated three main levels of motivation- intrinsic, extrinsic, and amotivation. Those who are intrinsically motivated perform activities and exhibit behaviors in the absence of external factors (Hill, 2013; Niemiec & Ryan, 2009; Ryan & Deci, 2000). In educational settings, students learn for the sake of learning the material, are more curious and interested in learning, and are less concerned about performance and grades (Deci & Ryan, 2008a; Hill, 2013; Lopez-Perez et al., 2011; Marchand & Gutierrez, 2012; Niemiec & Ryan, 2009; Ryan & Deci, 2000;

Vos et al., 2010). Intrinsic motivation increases in autonomy-supported learning environments and is associated with psychological well-being (Deci & Ryan, 2008a; Niemiec & Ryan, 2009). Learning environments that are controlling undermine the intrinsic motivation of a student (Deci & Ryan, 2008a; Lopez-Perez, 2011; Niemiec & Ryan, 2009; Ryan & Deci, 2000).

Extrinsic motivation refers to behaviors exhibited for the sake of some external reward or outcome that is separate from the activity (Hill, 2013; Niemiec & Ryan, 2009; Ryan & Deci, 2000). Ryan and Deci (2000) proposed a continuum of extrinsic motivation that includes external, introjected, identified, and integrated regulation. Those students who exhibit external and introjected regulation learn the material to avoid failure, earn a good grade, and/or avoid ridicule from parents or classmates (Hill, 2013; Niemiec & Ryan, 2009; Ryan & Deci, 2000; Vansteenkiste et al., 2009). Some subject matter may not be of interest, but learning the material must occur for that student to meet his or her educational goals (Baeten et al., 2010; Hill, 2013). These students exhibit identified and integrated regulation because the external factor for learning is internally regulated by the self (Niemiec & Ryan, 2009). Extrinsic motivation is necessary for students to complete educational activities that may not be interesting or enjoyable (Niemiec & Ryan, 2009). In comparison to intrinsic and extrinsic motivation, an amotivated student does not exhibit positive behaviors towards learning. The student does not want to learn regardless of the classroom environment and motivating or demotivating factors (Baeten et al., 2010; Lopez-Perez et al., 2011; Marchand & Gutierrez, 2012; Niemiec & Ryan, 2009; Deci & Ryan, 2008a).

Student motivation towards college learning can be assessed using the Academic

Motivation Scale for Colleges (AMS-C) (Hill, 2013; Lavender, 2005; Vallerand et al., 1993). This scale is designed to assess a student's academic motivation based upon Deci and Ryan's self-determination theory (Vallerand et al., 1993). Lavender (2005) found an "implication of intrinsic motivation being positively correlated with academic achievement" in an open-enrollment community college. Considering SDT, students with high GPAs and high intrinsic motivation should be both satisfied and successful with the classroom flip (Lavendar, 2005; Kiriakidis et al., 2011). However, the more important question is whether students with average to low GPAs and extrinsically motivated or exhibiting amotivation towards learning are both satisfied and successful with the classroom flip (Hill, 2013; Kiriakidis et al., 2011).

Learning environments and SDT. The learning environment affects student motivation (Araz & Sungur, 2007; Baeten et al., 2010; Baeten et al., 2012; Co, 2010; Overbaugh & Nickel, 2011; Rastegar et al., 2010). As the focal point and facilitator of the learning environment, the teacher is instrumental in implementing learning environments that are motivating and autonomy-supportive (Baeten et al., 2010; Baeten et al., 2013; Co, 2010; Overbaugh & Nickel, 2011; Rastegar et al., 2010). Those teachers who use autonomy-supportive teaching practices facilitate student internalization of academic motivation (Nie & Lau, 2010; Niemiec & Ryan, 2009; Rastegar et al., 2010). Students are more internally regulated when teachers provide students with challenging activities, appropriate learning tools, and feedback as well as how the content relates to his or her goals (Baeten et al., 2010; Niemiec & Ryan, 2009; Vos et al., 2011; Wijnia et al., 2011). Further, teachers who seek student input, use supportive language, and scaffold the implementation of student-centered learning are considered autonomy-supportive (Wijnia et al., 2011).

Teachers who provide encouraging versus controlling feedback cultivate students' individual improvement which influences intrinsic and autonomous motivation (Deci & Ryan, 2008a; Wijnia et al., 2011). Along with encouraging feedback, researchers found that a scaffolding approach to student-centered learning supports student learning and satisfaction with the learning environment (Wijnia et al., 2011). The learning environment becomes less structured by gradual introduction to constructivist learning (Araz & Sungar, 2007; Wijnia et al., 2011). The teacher's role gradually becomes learning facilitator or coach. Even with a scaffolding approach to student-centered learning, prior knowledge is foundational for successful implementation of a constructivist learning environment (Araz & Sungar, 2007; Kirschner et al., 2009; Wijnia et al., 2011). Many students are less motivated to learn in constructivist learning due to this lack of prior knowledge (Araz & Sungar, 2007; Kirschner et al., 2009; Wijnia et al., 2011). Some form of knowledge-transmission is an essential part of learning (Nie & Lau, 2010). Therefore, a mixture of knowledge-transmission to achieve prior knowledge and knowledge-construction can enhance the learning process and increase student motivation (Nie & Lau, 2011).

Constructivist learning environments that use technology to provide students autonomy in how he or she learns is a method to increase motivation (Harun et al., 2012; Lopez-Perez et al., 2011; Marchand & Gutierrez, 2012; Neo & Neo, 2009; Overbaugh & Nickel, 2011; Pham, 2012; Prakash, 2010; Vos et al., 2011). Students in blended, constructivist learning environments use critical thinking skills and self-regulated learning while engaged in active learning (Vos et al., 2011). But, the student's initial level of motivation can also effect student success and satisfaction in the constructivist learning environment (Hill, 2013; Lavender, 2005; Liu et al., 2012; Lopez-Perez et al., 2011; Ning & Downing, 2012; Rastegar et al., 2010; Soenens & Vansteenkiste, 2005; Vansteenkiste et al., 2009).

Deep Learning and the Learning Environment

The effects of the learning environment on students' learning approaches have been a topic of study for many decades (Baeten et al., 2013; Tynjala, 1999). Students approach learning in a variety of ways depending on the subject, learning environment, and student characteristics (Baeten et al., 2010; Baeten et al., 2013; Co, 2010; Felder, 2012; Lavasani & Ejei, 2011; Mazur, 2009; Nie & Lau, 2010; Prakash, 2010; Taylor & Parsons, 2011; Tynjala, 1999; Vos et al., 2010; Yang & Wu, 2012). Approaches to learning can be categorized as deep or surface learning processes (Baeten et al., 2010; Baeten et al., 2013; Co, 2010). When a student adopts a deep approach to learning, the student is intrinsically motivated to learn the material, relates ideas by weaving concepts together, and uses content to seek personal meaning and applicability (Baeten et al., 2013; Co, 2010). Conversely, students who use surface learning processes employ rote memorization are bound to learning what is listed on the syllabus, and are extrinsically motivated by fear of failure (Baeten et al., 2013; Co, 2010). A goal of higher education is to encourage the adoption of deep approaches to learning (Baeten et al., 2013; Co, 2010). Researchers have shown that learning environments affect students' approaches to the learning process (Baeten et al., 2010; Baeten et al., 2013; Co, 2010; Felder, 2012; Lavasani & Ejei, 2011; Mazur, 2009; Nie & Lau, 2010; Prakash, 2010; Taylor & Parsons, 2011; Tynjala, 1999; Vos et al., 2010; Yang & Wu, 2012).

Constructivist learning environments are student-centered and have been found affect students' learning (Baeten et al., 2010; Baeten et al., 2013; Co, 2010; Felder, 2012; Mazur, 2009; Nie & Lau, 2010; Prakash, 2010; Taylor & Parsons, 2011; Tynjala, 1999; Vos et al., 2010; Yang & Wu, 2012). In particular, a student's "approach to learning" is a way to describe their learning (Baeten et al., 2010; Baeten et al., 2013; Co, 2010). Deep, meaningful learning optimization has been attempted through the use of a constructivist learning environment (Baeten et al., 2010; Baeten et al., 2013; Co, 2010; Felder, 2012; Lavasani & Ejei, 2011; Mazur, 2009; Nie & Lau, 2010; Prakash, 2010; Taylor & Parsons, 2011; Tynjala, 1999; Vos et al., 2010; Yang & Wu, 2012). However, these efforts have been met with limited success (van Bommel et al., 2012; Kirschner et al., 2006).

While some researchers found that some students deepened their learning approaches (Baeten et al., 2010; Co, 2010; Musallam, 2010; Neo & Neo, 2009; Nie & Lau, 2010; Vos et al., 2010), other students increased surface approaches to learning (Baeten et al., 2010; Lavasani & Ejei, 2011), and yet other students did not change his or her learning in a constructivist learning environment (Baeten et al., 2010; Kirschner et al., 2006; van Bommel et al., 2012). To optimize learning in a constructivist learning environment, it is important to determine the factors that influence the adoption of a deep approach to learning as well as how these encouraging and discouraging factors influence students' approach to learning (Baeten et al., 2010; Lavasani & Ejei, 2011; Menchaca & Bekele, 2008).

A learner-centered environment may not be ideal for all courses (van Bommel et al., 2012; Kirschner et al, 2006). Students want to know why content is relevant in his or her personal and professional lives (Baeten et al., 2010; Co, 2010). Deeper learning increases as content relevance increases (Baeten et al., 2010; Koohang et al., 2009). Baeten et al. (2010) concluded that factors that influenced students' approaches toward deep learning through a constructivist learning environment are complex.

Factors affecting deep learning. Several factors affect students' approach to deep learning in a constructivist learning environment. One of the most influential factors that influence a deeper learning strategy is the instructor's approach to teaching (Baeten et al., 2010; Baeten et al., 2013; Menchaca & Bekele, 2008). If a teacher focused less on the transmission of knowledge, the learning deepened (Baeten et al., 2013; Baeten et al., 2010; Co, 2010; Lavasani & Ejei, 2011; Tynjala, 1999; Vos et al., 2010; Yang & Wu, 2012. Subject matter and discipline also influenced students' approach to learning (Baeten et al., 2010). Although students taking courses in the natural sciences showed a deeper approach to learning in some studies, this was not true in all studies (Baeten et al., 2010; Baeten et al., 2013).

Student perceptions of the learning environment also seemed to influence learning approaches. If the teaching approach was perceived to be teacher-centered, a more surface approach to learning was found in the literature (Baeten et al., 2010). Conversely, if the teaching approach was perceived to be learner-centered, a deeper approach to learning resulted (Baeten et al., 2013). Course applicability to the student's profession was found to influence the learning approach (Baeten et al., 2010). Student's intellectual ability, abstract reasoning, and level of cognitive development were not confirmed to be a positive influence on deep learning by all studies (Baeten et al., 2010; Baeten et al., 2013).

Motivation was found to be related to the learning approach (Baeten et al., 2010).

Amotivated learners preferred teacher-centered learning environments and learning that focused on the transmission of information and promoted rote learning (Baeten et al., 2010). Those students who were intrinsically motivated developed a deeper approach to learning in the learner-centered environment. Student-centered learning environments were expected to promote students' adoption of deeper approaches to learning, but Baeten et al. (2010) concluded that the findings were inconclusive. As a result of the literature review, Baeten et al. (2010) suggested conducting quasi-experimental research to determine which contextual factors most influence deep learning.

Individual student characteristics such as student motivation towards learning the material strongly influenced deeper approaches to learning (Lopez-Perez et al., 2011; Marchand & Gutierrez, 2011; Niemiec & Ryan, 2009; Ning & Downing, 2012). If the students perceived the course as relevant to their professional practice, the student approached the learning at a deeper level (Baeten et al., 2010). Individual student factors such as age, gender, intellectual ability, and level of academic motivation affected the students' approach to learning (Baeten et al., 2010; Lopez-Perez et al., 2011; Marchand & Gutierrez, 2011; Niemiec & Ryan, 2009; Ning & Downing, 2012). In addition, a motivating instructor also seemed to play a role in how students approach learning the material (Baeten et al., 2010; Pham, 2012; Vansteenkiste et al., 2009).

The constructivist learning is not a "one size fits all" learning environment and students' individual characteristics such as level of academic motivation will influence satisfaction and success (Baeten et al., 2010; Lopez-Perez et al., 2011; Marchand & Gutierrez, 2011; Niemiec & Ryan, 2009; Neo & Neo, 2009; Nie & Lau, 2010; Ning & Downing, 2012; Pham, 2012; Vansteenkiste et al., 2009). Baeten et al. (2010) also indicated that the nature of the discipline and autonomous learning helped to cultivate certain approaches to learning.

When students experience autonomy, students are more satisfied with the learning experience (Acat & Donmez, 2009; Harun et al., 2012; Soenens & Vansteenkiste, 2005; Vos et al., 2010). Conversely, students perceived the teacher-centered learning environment more negatively than the learner-centered learning environment (Acat & Donmez, 2009). A more structured, teacher-centered learning environment inhibits individualized learning and decreases autonomy (Brunsell & Horejsi, 2011; Deci & Ryan, 2008a). These findings supported the constructivist learning theory that students develop a deeper understanding of topics when a student-centered learning environment is applied (Acat & Donmez, 2009; Carini et al., 2006; Menchaca & Bekele, 2008; Vos et al, 2010; Yang & Wu, 2012). While student satisfaction and the development of a deeper understanding of concepts are important in education, achievement in terms of assessment scores is equally important (Araz & Sungar, 2010; Sesen & Tarhan, 2010; Vos et al., 2010). Student success can be determined through test scores such as posttests or final exams (Lavasani & Ejei, 2011; Rastegar et al., 2010).

Motivation, Success, and the Learning Environment

With the increase in blended learning options, researchers sought to determine which factors most influenced student achievement in the blended learning environment (Baeten et al., 2010; De George-Walker & Keeffe, 2010; Donnelley, 2010; Lopez-Perez et al., 2011; Nie & Lau, 2010; Ning & Downing, 2012; Taylor & Parsons, 2011). Level of achievement in education is typically measured by assessment scores (Rastegar et al., 2010). Kiriakidis et al. (2011) examined the effects of grade point average (GPA) on courses taken either in the traditional setting or online by undergraduate working adults. Grade point average was found to be the single best predictor of student achievement within both F2F and online learning environments (Lavendar, 2005; Kiriakidis et al., 2011; Ning & Downing, 2012).

Grade point average is positively correlated with motivation on the self-determination theory continuum (Lavender, 2005; Ning & Downing, 2012; Soenens & Vansteenkiste, 2005). High levels of SDT functioning, specifically intrinsic motivation, results in higher GPA (Lavender, 2005; Ning & Downing, 2012; Soenens & Vansteenkiste, 2005). In addition, researchers found that students with low levels of motivation performed less optimally than those students with a higher level of motivation and that motivation played a mediating role in the relationship between learning experience and cumulative GPA (Liu et al., 2012; Nie & Lau, 2010; Ning & Downing, 2012). Lavender (2005) found an "implication of intrinsic motivation being positively correlated with academic achievement" in an open-enrollment community college. To that end, students' test scores should be influenced by the level of academic motivation as GPA is the result of earned grades in college courses (Baeten et al., 2010; De George-Walker & Keeffe, 2010; Donnelley, 2010; Lopez-Perez et al., 2011; Nie & Lau, 2010; Ning & Downing, 2012; Taylor & Parsons, 2011).

Success and the learning environment. Test scores and GPA are measures used to report student success (Sesen & Tarhan, 2010; Kiriakidis et al., 2011). High student success rates are indicative of a successful learning environment (Sesen & Tarhan, 2010; Kiriakidis et al., 2011). The flipped classroom is an environment that blends F2F and online learning resulting in a blended, constructivist learning environment (Felder, 2012;

Bergmann & Sams, 2012). Grade point average was found to be the single best predictor of student achievement within both F2F and OL environments (Kiriakidis, et al., 2011).

Sesen and Tarhan (2010) conducted a between-subjects quasi-experimental study to investigate the effects of active learning applications on learning achievement and attitudes toward chemistry. High school chemistry students were more successful in a constructivist learning environment compared to those students in a traditional lecture learning environment (Sesen & Tarhan, 2010). Final scores are important when determining student success, but learning gains are equally indicative of student success (Prakash, 2010).

Pre- and posttest score comparisons can support or refute gains in learning (Jackson, 2012; Lasry et al., 2008; Musallam, 2010; Overbaugh & Nickel, 2011; Prakash, 2010; Vos et al., 2010). Gains in learning with respect to learning environments are determined by comparing means of pre-and posttests (Prakash, 2010; Vos et al., 2010). Through the posttest results, Prakash (2010) revealed that the bachelor degree students had higher gains in knowledge in a constructivist learning environment. Even though short term learning appeared to be greater using a constructivist learning model, posttests administered four months later indicated that neither group's scores differed significantly (Prakash, 2010).

Despite the short-term increases in learning, researchers indicated that students were more satisfied with the constructivist learning environment (Prakash, 2010; Overbaugh & Nickel, 2011; Vos et al., 2010). A significant increase in student learning using the constructivist model will occur only if entire courses are designed and delivered based on constructivist principles (Armaral & Shank, 2010; Prakash, 2010; Vos et al., 2010). In order for real learning to occur, the learner has to ultimately construct his or her own mental models of the external world over a period of time (Felder, 2012; Harun et al., 2012; Prakash, 2010; Prince & Felder, 2007; Sjober, 2007). This requires intrinsic motivation and self-efficacy (Deci & Ryan, 2008a). However, students taking courses that are not perceived relevant to the major of study may not be as motivated to construct ideas (Baeten et al., 2010).

Motivation and the learning environment. As part of graduation, many students in secondary and post-secondary education are required to take several science and mathematics courses (Acat & Donmez, 2009; Mazur, 2009; Prakash, 2010; Sesen & Tarhan, 2010; Yang & Wu, 2012). Problem-based learning is easily implemented in science courses due to the nature of scientific investigations (Araz & Sungar, 2010; Mazur, 2009; Prince & Felder, 2007; Ruiz-Gallardo et al., 2011). Araz and Sungar (2010) determined that learning environments had direct or indirect effects on self-efficacy and success in a genetics course. Researchers posited that students in an active learning environment use deeper learning strategies and are more successful (Araz & Sungar, 2010; Baeten et al., 2010; Harun et al., 2012; Neo & Neo, 2009; Nie & Lau, 2010; Vos et al., 2010; Yang & Wu, 2012). Further, students are more intrinsically motivated to learn in an autonomous learning environment (Araz & Sungar, 2010; Baeten et al., 2010; Deci & Ryan, 1985; Harun et al., 2012; Neo & Neo, 2009; Nie & Lau, 2010; Vos et al., 2010; Yang & Wu, 2012). Researchers' findings supported the constructivist theory that when students learn in an active learning environment, deeper learning is attained (Neo & Neo, 2009; Nie & Lau, 2010) and also with the self-determination theory that suggests that students are more intrinsically motivated to learn in an autonomous learning environment (Deci & Ryan, 1985).

Motivation and achievement. A student's self-efficacy and good quality motivation should be positively correlated with achievement (Marchand & Gutierrez, 2011; Niemiec & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009). Students often cite test anxiety as the cause of poor achievement on high-stakes assessments like tests and final exams (Lavasani & Ejei, 2011; Rastegar et al., 2010). The root of text anxiety can be attributed to the quality of motivation (Lavasani & Ejei, 2011; Niemiec & Ryan, 2009).

Students who approached learning with the goal of mastery had less test anxiety and an increase in intrinsic motivation (Lavasani & Ejei, 2011; Liu et al., 2012; Niemiec & Ryan, 2009; Ning & Downing, 2012; Rastegar et al., 2010). Conversely, students who avoided performance employed superficial learning strategies, were less intrinsically motivated, and had an increase in test anxiety (Lavasani & Ejei, 2011; Niemiec & Ryan, 2009). These findings are aligned with SDT in that students' individual characteristics affect learning achievement (Lavasani & Ejei, 2011; Niemiec & Ryan, 2009; Deci & Ryan, 2008a; Soenens & Vansteenkiste, 2005; Vansteenkiste et al., 2009).

Mathematics is notoriously a difficult subject and many learners do not perform well (Lavasani & Ejei, 2011; Rastegar et al., 2010; Strayer, 2012). Poor mathematics achievement may be related to the level of motivation to learn mathematical concepts (Rastegar et al., 2010). Researchers found that students' math performances were influenced by the level of motivation and learning strategies (Lavansani & Ejei, 2010; Rastegar et al., 2010; Vansteenkiste et al., 2009). Further, mathematics achievement was mediated by a student’s level of motivation and learning strategies (Lavansani & Ejei, 2010; Rastegar et al., 2010; Vansteenkiste et al., 2009). As discussed, intrinsic motivation is correlated with autonomous learning such as provided in the constructivist learning environment (Araz & Sungar, 2010; Baeten et al., 2010; Deci & Ryan, 1985; Harun et al., 2012; Neo & Neo, 2009; Nie & Lau, 2010; Vos et al., 2010; Yang & Wu, 2012). While most researchers investigated the level of motivation as a dependent variable, only a few researchers considered the level of motivation as the independent variable or covariate (Ning & Downing, 2012; Vansteenkiste et al., 2009).

Researchers found that autonomous motivation was positively correlated with time and environment use, effort regulation, meta-cognitive strategy use, and GPA whereas controlled motivation was negatively correlated with these items (Lavendar, 2005; Niemiec & Ryan, 2009; Ning & Downing, 2012; Rastegar et al., 2010; Vansteenkiste et al., 2009). Further, autonomous motivation was negatively correlated with procrastination, cheating attitude, and cheating behavior whereas controlled motivation was positively correlated with these items (Vansteenkiste et al., 2009). Autonomous motivation was positively correlated with cognitive processing whereas controlled motivation was positively correlated with test anxiety (Niemiec & Ryan, 2009; Vansteenkiste et al., 2009. In addition, GPA is positively correlated with motivation on the self-determination theory continuum (Lavender, 2005). High levels of SDT functioning, specifically intrinsic learner motivation result in higher GPA (Lavender, 2005; Lopez-Perez, 2011; Soenens & Vansteenkiste, 2005).

Motivation, Satisfaction, and the Learning Environment

With the proliferation of multimedia technologies in the classroom, teaching and learning opportunities using constructivist learning environments are on the rise (De

George-Walker & Keeffe, 2010; Heilesen, 2010; Kiriakidis et al., 2011; Koohang et al., 2009; Neo & Neo, 2009; Taylor & Parsons, 2011). Multimedia technologies can aid in stimulating the learning process in a student-centered learning environment (De George-Walker & Keeffe, 2010; Harun et al., 2012; Heilesen, 2010; Kiriakidis et al., 2011; Koohang et al., 2009; Neo & Neo, 2009; Pursel & Fang, 2012; Sutton-Brady et al., 2009; Taylor & Parsons, 2011; Yang & Wu, 2012). Learning motivation levels were found to be very high and students indicated that multimedia-based projects enhanced student performance and provided stimulation in the learning process (Neo & Neo, 2009; Yang & Wu, 2012). However, students expressed dissatisfaction and a decrease in motivation when the group work became disagreeable (Neo & Neo, 2009).

Motivation to learn increases when a student sees a purpose aligned with his or her academic goals and profession (Baeten et al., 2010). While a multimedia project is applicable in a course specifically designated as an interactive multimedia course, content in elective science courses may not be as easily delivered using group projects (Armaral & Shank, 2010; Mora, 2010; Moss & Crowley, 2011; Sesen & Tarhan, 2010). Learning experience (satisfaction) and achievement are affected by levels of motivation (Ning & Downing, 2012; Vansteenkiste, et al., 2009). Learning environments also influence student learning and success (Baeten et al., 2010; Ning & Downing, 2012; Vansteenkiste, et al., 2009).

Researchers found that student self-regulation and the level of academic motivation were intervening mediators and moderator variables in students' learning experience (satisfaction) and achievement (Ning & Downing, 2010). Ning and Downing (2010) concluded that learning experiences affect student motivation and self-regulation which in turn affects success. Ning & Downing (2010) posited that educators should provide constructivist learning environments that enhance student motivation and self-regulation (Ning & Downing, 2010). As a result of a quasi-experimental study, Ning and Downing (2010) provided evidence that the level of motivation influenced the relationship between learning environment and student success and satisfaction with final-year bachelor degree students. Ning and Downing (2010) suggested that similar studies should be conducted in 100-level college courses to determine if the level of motivation influences the relationship between a constructivist learning environment and success and satisfaction.

Likewise, students' perceptions of the teaching climate may be influenced by the students' level of motivation (Vansteenkiste et al., 2009. In other words, those students who are initially more intrinsically motivated to take a course and learn the concepts may perceive the teaching climate more favorably (Vansteenkiste et al., 2009). This hypothesis was confirmed by researchers who found that high quantity motivation group displayed the second most optimal pattern of educational outcomes, followed by the low quantity motivation group and the poor quality motivation groups (Niemiec & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009). These findings are aligned with this study's hypothesis that a student's level of academic motivation will influence student achievement and success (Lavasani & Ejei, 2011; Nie & Lau, 2010; Niemiec & Ryan, 2009; Deci and Ryan, 2008b; Soenens & Vansteenkiste, 2005; Vansteenkiste et al., 2009).

Researchers have found that an active learning environment increased student motivation levels and education outcomes (Araz & Sungar, 2007; Marchand & Gutierro, 2011; Sesen & Tarhan, 2010; Vos et al., 2010; Yang & Wu, 2012). Other researchers revealed that students' level of academic motivation influenced student achievement and success (Lavasani & Ejei, 2011; Niemiec & Ryan, 2009; Ning & Downing, 2012; Rastegar et al., 2010; Vansteenkiste, et al., 2009), but none of these researchers considered the learning environment. While level of academic motivation has been found to increase in a constructivist learning environment, there is little research that considers motivation as an independent variable that affects satisfaction and ultimately influences achievement in a constructivist learning environment (Ning & Downing, 2012).

Summary

The flipped classroom learning environment is grounded in the constructivist theory of learning (Felder, 2012). Constructivism has been difficult to implement due to the need for prior knowledge to exist in order for learners to construct ideas from this knowledge (Kirschner et al., 2006; van Bommel et al., 2012). While constructivist learning environments such as PBL, PI, educational gaming and storytelling, and the flipped classroom are practical applications of constructivist learning, data indicating student success and satisfaction with these applications of constructivism have been inconsistent (Baeten et al., 2012; Baeten et al., 2013; Berrett, 2012; Co, 2010; Felder, 2012; Harun et al., 2012; Lasry et al., 2008; Mazur, 2009; Nie & Lau, 2010; Prince & Felder, 2006; Vos et al., 2011; Wijnia et al., 2011; Yang & Wu, 2012). Specifically, the previously discussed flipped classroom studies were conducted at competitive higher educational or K-12 institutions and students' individual characteristics were not considered (Aramaral & Shank, 2010; Bergmann & Sams, 2012; Lage et al., 2000;

Musallam, 2010; Strayer, 2012; Zappe et al., 2009).

Despite the attention that the flipped or inverted classroom has been getting in mainstream media and educational blogs (Thompson, 2011; Toppo, 2011; WSJ, 2012; Young, 2012), faculty have been uncertain as to whether the flipped classroom directly impacts student achievement and satisfaction (Aramaral & Shank, 2010; Bergmann & Sams, 2012; Lage et al., 2000; Musallam, 2010; Strayer, 2012; Zappe et al., 2009). There is little evidence identifying which courses are best suited for the flipped classroom (Strayer, 2012) or whether motivation influences achievement and satisfaction (Ning & Downing, 2012). Researchers have shown some success with the flipped model in high school advanced placement courses (Musallam, 2010) as well as college-level physics, engineering, statistics, and economics courses (Mazur, 2009; Zappe, et al., 2009; Strayer, 2012; Lage, et al., 2000). However, Crouch and Mazur (2001) found less success with peer instruction, a constructivist learning model, among non-science majors taking a physics course. Albrecht (2006) also reported student dissatisfaction with content delivery outside of class via e-learning, as students seemed to be resistant to the constructivist learning approach in class and were more satisfied with the role of passive-learner.

A need exists for a study to determine if the classroom flip is a viable instructional model for elective science courses intended for non-science majors (Strayer, 2012; Zappe et al., 2009). The results from this study could assist instructors in determining whether elective science courses are suited for the classroom flip in terms of student achievement and satisfaction. Having such knowledge could save time and money for those who might consider adopting the flipped classroom instructional model in an elective science course. The results may also help future adopters of the flipped classroom predict which students may be less successful with the classroom flip and help transition these students from passive to active learners (Vansteenkiste et al., 2009). It is imperative for future adopters of the flipped classroom to know if the flipped classroom increases student achievement and satisfaction regardless of pre-knowledge and student academic motivation (Berrett, 2012; Strayer, 2012; Vos et al., 2010; Zappe et al., 2009).

Chapter 3: Research Method

The flipped or inverted classroom is a modification of student-centered instructional models that have been in existence for many years (Felder, 2012). The flipped or inverted classroom has evolved over the years from instructional models that have included problem-based learning (PBL), inquiry learning, just-in-time teaching (JiTT), process oriented guided inquiry learning (POGIL), and peer instruction (PI) (Crouch & Mazur, 2001; Prince & Felder, 2006; Prince & Felder, 2007). The flipped classroom is an instructional model in which the traditional lecture is a student's homework and in-class time is spent on collaborative, inquiry-based learning (Bergmann & Sams, 2012). These student-centered instructional models, including the flipped classroom, are founded on the constructivist theory of learning (Felder, 2012; Gordon, 2008; Perkins, 1999; Strayer, 2012). The core idea of constructivism applied to learning is that the environment is learner-centered where knowledge and understanding is socially constructed (Felder, 2012; Perkins, 1999; Sternberg, 2008).

Over the years, educators have sought methods for applying the constructivist theory to the classroom (Sternberg, 2008). The flipped classroom instructional model capitalizes on the increased opportunities for constructivist learning that technology has provided (Koohang et al., 2009; Neo & Neo, 2009; Vos et al., 2010). Instructors who infuse technology into his or her teaching are able to deliver content outside of class so that F2F time can be spent interacting with the content (Bergmann & Sams, 2012; Koohang et al., 2009). Interactivity occurs in the F2F classroom when the students work collaboratively to solve problems, evaluate, and synthesize ideas and concepts. Learning deepens with the collaborative, interactive relationships that develop between students and teachers (Baeten et al., 2010; Brunsell & Horejsi, 2011).

Engagement in the F2F environment has been difficult to achieve because students must enter this environment with foundational concepts established (Nie et al., 2010). With the proliferation of Web 2.0 technologies such as podcasts and vodcasts, delivering content prior to the F2F classroom has become easier (Koohang et al., 2009; Nie et al., 2010; Vos et al., 2010). Pod- and vodcasts have been found to be effective pedagogical tools, and when used in conjunction with a collaborative, engaging F2F learning environment, a "perfect storm" of technology and constructivism has produced the flipped classroom instructional model (Young, 2012). Today's students have grown up with technology and use it in their personal lives to connect with friends (Tapscott, 2009). Utilizing these native tools in a student's learning process makes pedagogical sense (Tapscott, 2009).

The student population in higher education of today has been branded the "Net Generation" (Prensky, 2001). These students are digital natives who use technology to construct their own knowledge and ideas based on the information encountered through technology and social media (Beyers, 2009; Oblinger & Oblinger, 2005; Prensky, 2001; Roberts, 2010; Tapscott, 2009). Therefore, the Net Generation of learners should be more satisfied and successful in the flipped classroom model (Beyers, 2009). However, several researchers indicated that some students were not as satisfied with the classroom flip and preferred the traditional lecture (Albrecht, 2006; Crouch & Mazur, 2001; Lage et al., 2000; Strayer, 2012; Zappe et al., 2009). The flipped classroom has been studied in courses such as advanced placement chemistry, microeconomics, statistics, physics, and engineering at competitive higher educational institutions and with academically motivated high school students where researchers reported an increase in student success (Crouch & Mazur, 2001; Lage et al., 2000, Musallam, 2010; Strayer, 2012; Zappe et al., 2009). Studies have not been conducted in science courses intended for the non-science major at an open-enrollment college. While the academically average student may benefit from the flip, it is possible the level of a student's academic motivation may influence achievement and satisfaction with the flipped classroom model (Baeten et al., 2010; Carini et al., 2006; Kirschner et al., 2006; Lavender, 2005).

Statement of the Problem

Despite the attention that the flipped or inverted classroom has been getting in mainstream media and educational blogs (WSJ, 2012; Young, 2012), researchers have been uncertain as to whether the flipped classroom environment increases student achievement (Merrill, 2008; Vos et al., 2010; Zappe et al., 2009) and student satisfaction within the learning environment (Strayer, 2012; Zappe et al., 2009) for students with varying academic preparedness and motivation levels. Student intrinsic motivation increases in a constructivist learning environment, but researchers have not indicated if student motivation mediates achievement or satisfaction in a constructivist learning environment such as the flipped classroom (Baeten et al., 2010; Sesen & Tarhan, 2010; Vansteenkiste et al., 2009; Vos et al., 2010).

The specific problem with the flipped classroom is two-fold. One problem is that there is little evidence that indicates whether students are more successful in the flipped classroom learning environment compared to the traditional lecture environment (Lage et al., 2000; Mazur, 2009; Strayer, 2012; Zappe et al., 2009). Another problem is that not all learners are prepared academically or have the motivation needed to perform successfully in the constructivist learning environment (Kirschner et al., 2006; Lavasani & Ejei, 2011; Liu et al., 2012). The level of academic motivation and pre-knowledge may influence student achievement with the flipped classroom and influence students' satisfaction with the flipped classroom (Niemic & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009). Further, researchers have not flipped a class at an open-enrollment college in science classes where students have a wide-range of academic motivation levels. Determining whether the flipped classroom increases student satisfaction and achievement in elective science courses where students' individual characteristics vary is imperative to future applications of the classroom flip (Strayer, 2012; Zappe et al., 2009).

Purpose of the Study

The purpose of this quantitative study was to investigate the constructivist learning theory by comparing the flipped classroom learning environment with the traditional lecture learning environment. A comparison was made using posttest scores and student satisfaction with both instructional models, while considering the level of student academic motivation and pre-knowledge amongst non-science students taking an elective science course at an open-enrollment college. A minimum sample of 55 students at Pennsylvania College of Technology (Penn College) in Williamsport, Pennsylvania was needed to voluntarily enroll based upon personal interest in the course Introduction to Environmental Science (Environmental Science).

The pre- and posttest scores were recorded and compared in both the flipped and traditional learning environments. Satisfaction with the flipped classroom and traditional lecture models was measured using modified items from the College and University

Classroom Environment Inventory (CUCEI) with Likert-scale response choices (Fraser, Treagust, & Dennis, 1986; Strayer, 2012). The level of student self-determination (motivation) was considered a possible covariate that may influence student satisfaction with and achievement in the flipped classrooms (Ning & Downing, 2012; Vansteenkiste et al., 2009). The level of self-determination was determined prior to the commencement of the study using the Academic Motivation Scale- College Version (AMS-C) (Lavender, 2005; Vallerand, Pelletier, Blais, Briere, Senecal, & Vallieres, 1993; Vos et al., 2010).

Research Questions and Hypotheses

The following research questions were addressed in a science course intended for non-science major students at the open-enrollment, technical college studied.

Q1. After controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college?

H1$_0$: There is no difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in science knowledge and academic motivation.

H1$_a$: There is a difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in environmental science knowledge and academic motivation.

Q2. After controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in satisfaction between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college?

H2o. There is no difference in satisfaction with environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in science knowledge and academic motivation.

H2a. There is a difference in satisfaction with environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in environmental science knowledge and academic motivation.

Chapter three provides an overview of the research method. Reasons for the research design, context for the study, the population, and sample are outlined. Due to the many design choices and convenience sample, justifications for these choices are listed. Good quantitative research involves a thorough consideration of independent and dependent variables. Therefore, an overview of the instruments for measuring the variables and covariates is provided followed by a section dedicated to the operational definitions of the variables. To fully understand the scope of this study, the methods for collection, measurement, and analyses of these variables are outlined. Finally, the assumptions, limitations, delimitations, and ethical assurances will be described and discussed.

Research Methods and Design

This quantitative study was designed as a nonequivalent between-subjects quasi-experiment to test the constructivist learning theory by comparing the flipped classroom model with the traditional lecture model with respect to posttest scores and student satisfaction with a group of non-science students taking an elective science course at an open-enrollment college. Level of academic motivation and pre-knowledge were examined as possible covariates for student satisfaction and achievement in a flipped classroom. For comparison, two convenience groups of 26 and 23 students in a lecture and flipped classroom Environmental Science class respectively were studied. All students at Penn College are required to take a three credit science class. Many elect to take Environmental Science as it has no pre-requisite course requirements. Thus, students in this course are more likely to represent the population demographics at Penn College than other elective science courses.

In order to fully compare learning environments, subjects in the two groups were exposed to each learning environment separately (Black, 2002; Gonzalez & Griffin, 2002). When one group does not receive the treatment it is considered the control and the other group exposed to a treatment, is considered the experimental group (Black, 2002). This scenario is considered an experimental design. In a true experiment, participants in subjects in both groups are assigned based upon pre-existing characteristics to ensure group equivalency (Black, 2002; Musallam, 2010). However, due to the nature of educational environments, the students cannot be randomly assigned to groups or classes (Black, 2002; Jackson, 2012). Therefore, this study is considered a quasi-experiment (almost experiment) design (Black, 2002).

Since students self-enroll in Environmental Science, the flipped classroom group and traditional lecture groups were non-randomly assigned (Black, 2002). However, the students in both groups were from the same population of Penn College students and represent this population. To ensure group equivalency, supporting information about the subjects' characteristics in both groups was determined by a pretest and the AMS-C survey. This is a typical scenario in educational research as generally students cannot be randomly assigned to a class (Black, 2002; Gonzalez & Griffin, 2002).

The treatment occurred over a 16-week semester beginning in January 2014 and ending in May 2014. The treatment group was taught environmental science content using the flipped classroom learning environment and the control group was taught using the traditional lecture learning environment. Three unit exams and a cumulative final exam aligned with the course outcomes were administered during the 16-week semester to both groups. For optimal performance, researchers suggested that students need time to adjust to the flipped classroom learning environment (Bergmann & Sams, 2012; Strayer, 2012). For this reason, the students enrolled in the flipped classroom experienced the flipped classroom learning environment for the entire semester as opposed to only one unit or section.

A pretest was administered to the both the control and treatments groups during week one of the semester to determine Environmental Science pre-knowledge and was used to determine student achievement in flipped classroom learning environment (Black, 2002; Gonzalez & Griffin, 2002). The pre- and posttest questions were aligned with the course outcomes. The results of the pretest had two purposes. The pretest results helped establish group equivalency and are considered a pre-knowledge covariate. Since the level pre-knowledge is considered a covariate for student achievement and satisfaction in the flipped classroom compared to the traditional lecture model, group equivalency should be considered before treatment (Black, 2002; Gonzalez & Griffin, 2002). Further, the measurement of pre-knowledge as a covariate helped answer Q1 and Q2. Each group was measured twice; before and after the instructional models are applied (Black, 2002).

Pretest-posttest quasi-experimental designs are used measure a change in a variable (Black, 2002). A posttest, identical to the pretest, was administered to determine content knowledge gained and ultimately, student achievement, in both the traditional lecture environment and the flipped classroom lecture environment. Achievement can be measured in the context of pre-knowledge therefore; students in the both groups were initially assessed on the course outcomes (Musallam, 2010; Rastegar et al., 2010; Ruiz-Gallardo et al., 2011; Sesen & Tarhan, 2010). As the dependent variable in Q1, the pretest in conjunction with the posttest results, helped answer Q1. The differences in scores were used to compare student achievement in the flipped and traditional classes as indicated in Q1. This method was suggested by Black (2002) as a way to measure a dependent variable upon treatment.

The level of student academic motivation was measured prior to the start of the semester to determine if the level of academic motivation influences student achievement in and satisfaction with the flipped classroom learning environment (Black, 2002;

Gonzalez & Griffin, 2002; Ning & Downing, 2012). As the covariate, the measurement of motivation helped answer Q1 and Q2. Further, initial assessment of pre-knowledge and level of motivation helped determine group equivalency (Black, 2002).

Satisfaction with the learning environments was measured using the results from the CUCEI questionnaire and is considered the dependent variable in Q2. After the completion of all course content, students in both the treatment and control groups were sent a CUCEI questionnaire via the Qualtrics survey software. The results from the CUCEI survey established the level of student satisfaction with the flipped learning environment (Strayer, 2012) compared to student satisfaction in the traditional lecture environment. This method was suggested by Black (2002) as a way to measure a dependent variable upon treatment.

The AMS-C and CUCEI surveys were administered by the researcher using Qualtrics survey software and were sent to enrolled students through the Penn College's email system. Penn College has a site license for Qualtrics software. Qualtrics is a web-based software program that allows a researcher to collect data through an electronic survey assessment (Qualtrics, 2013). All surveys were sent to potential respondents electronically.

Population

The population from which a sample was selected for this study includes full- and/or part-time Penn College students. Penn College offers Bachelor and Associate degrees as well as non-degree and certificate programs. In the spring 2014 semester, there were 5,638 students consisting of 62.50% male and 37.50% female where 10.68% are minorities (Penn College, 2014). Most Penn College students are from North Central

Pennsylvania (42.11%), as well as other parts of Pennsylvania (42.64%) (Penn College, 2014). There are currently six schools within the Penn College institution. These include Health Sciences, Industrial, Computing & Engineering Technologies, Construction and Design Technologies, Sciences, Humanities & Visual Communications, Transportation & Natural Resources Technologies, and Business & Hospitality. The demographics in the study sample corresponded with the population at Penn College.

All Bachelor and Associate degree students at Penn College are required to take one 3-credit science course for graduation. Several degrees have a directed science course as part of the degree graduation requirements. However, many Bachelor and Associate degrees do not have prescribed science courses. These students can choose any science-elective to fulfill the graduation requirements for the degree. Many of these students choose to take Environmental Science as his or her science-elective. In addition, many students choose to take Environmental Science as his or her open-elective even if the science requirement was met with other science courses. To that end, students who select to enroll in Environmental Science come from a wide range of backgrounds. Further, students from this population should have a wide range of academic motivation towards being in college.

Sample

Both Musallam (2010) and Strayer (2012) reported that the classroom flip produced statistically significantly effects on achievement and satisfaction. When comparing the flipped and traditional classrooms, an independent *t* test of the posttest scores produced a 0.94 effect size (Musallam, 2010). Similarly, Strayer (2012) reported significant differences in aspects of the learning environment. Using the results from the

MANOVA, the learning environment explained 44.5% of the overall variation. Vansteenkiste et al. (2009) reported significant differences in learning outcomes with respect to motivation levels. Using the results from the ANOVA, the quality of motivation explained 76% of the overall variation (Vansteenkiste et al., 2009).

A power analysis was performed to determine optimal sample size for null hypotheses 1 and 2. Using the G*Power software, an ANCOVA statistical test was chosen. Since the effect sizes in the above cited literature was found to be high, the effect size in the a priori analysis was set to the large level of 0.4. The input parameters were set to $\alpha = 0.05$, $\beta = 0.8$, and number of covariates = 2. Using an *a priori* analysis with the conditions stated above, a minimum sample size of $N = 55$ was required to have an optimal chance of rejecting hypotheses 1 and 2.

Students generally enroll in Environmental Science to fulfill a three credit science elective requirement for graduation. Class schedules are determined by the student with assistance from his or her advisor. All students enrolled in an associate or bachelor degree program are required to take a three credit science course. This was a sample of convenience and in a given 16-week semester no more than 35 students are enrolled in one section of an Environmental Science course. Therefore, the combination of the control and experimental groups (two sections) should provide a maximum sample of $N = 70$. This maximum sample size was adequate to analyze both hypotheses for this study.

Several majors at Penn College are required to take specific science courses such as chemistry, physics, biology, and anatomy and physiology. Other majors do not have these science courses pre-determined in his or her degree plan. To that end, many students choose to take Environmental Science as his or her required 3-credit science course and as a result, the participants were non-randomly selected based upon self-enrollment in the course. Students who chose to take this course are enrolled in a variety of majors at Penn College such as graphic design, food and hospitality, networking, accounting, business, construction management, and paralegal. Since Penn College is an open-enrollment institution, the student population has a wide range of academic preparedness and levels of academic motivation (Penn College, 2014). Students who enroll in Environmental Science better represent the population of Penn College students than those students taking courses required for a degree major.

The Environmental Science course was selected for this study based upon the supporting information in the literature review. The literature shows some student success and satisfaction in the constructivist learning amongst students who are majoring in a science field, but the flipped classroom has not been studied in an elective science course. Students taking chemistry, physics, or biology as a required science course may view it as relevant for future professions and be more motivated to learn the content (Baeten et al., 2010). As discussed above, students taking Environmental Science do so by choice and represent a wide range of majors. Further, the course instructors have taught the course consistently at Penn College for over a decade. Since the course content was very familiar to the instructors, a lack of content knowledge was not a factor in the study.

Materials/Instruments

The level of motivation was considered a covariate with regard to both Q1 and Q2. The level of motivation was determined using the AMS-C (Appendix A) developed by Vallerand et al. (1993) prior to the commencement of the study. This scale is designed to assess a student's academic motivation based upon Deci and Ryan's self-determination theory (Lavendar, 2005; Vallerand et al., 1993; Vansteenkiste et al., 2009). The level of academic motivation is considered ratio.

Academic motivation is divided into categories that correspond with the AMS-C (Vallerand et al., 1993). These include: 1. Intrinsic motivation- to know; 2. Intrinsic motivation- toward accomplishment; 3. Intrinsic motivation- to experience stimulation; 4. Extrinsic motivation- identified; 5. Extrinsic motivation- interjected; 6. Extrinsic motivation- external regulation; and 7. Amotivation. The seven subscales of the AMS-C have an internal consistency ranging from .83 to .86 (Cokley, 2000). For this study, the categories of motivation were combined into one self-determination index as prescribed by authors and researchers using the AMS-C survey (A. St-Louis, personal communication, February 7, 2014). The formula used to determine this self-determination index (motivation) is as follows: 2((know+acc+stim/3)) + iden - ((intro+reg/2) + 2amo) = self-determination index where know= intrinsic motivation to know, acc= intrinsic motivation to accomplishments, stim= intrinsic motivation to experience stimulation, iden= identification; intro= introjected, regulation, reg= external regulation, and amo= amotivation (A. St-Louis, personal communication, February 7, 2014).

Prior to the start of the course, students in the flipped classroom took a pretest to assess pre-existing environmental science knowledge with respect to the course outcomes. The pretest score was considered a covariate with respect to Q1 and Q2. The pretest consisted of 27 multiple choice questions (Appendix B). To answer Q1, students took the posttest in the form of a final exam. The posttest consisted of identical questions as the pretest, but both the questions and answer choices were scrambled and administered approximately 16 weeks apart. Pretest and posttest scores were considered ratio and ranged from 0-100%.

With regard to Q2, satisfaction with the flipped classroom was determined using a satisfaction survey adapted from the CUCEI questionnaire (Appendix C) (Fraser et al., 1986) and is considered the dependent variable. The CUCEI was designed to measure students' perceptions of his or her actual learning environment (Fraser & Treagust, 1986; Fraser et al., 1986; Strayer, 2012). The CUCEI is considered ordinal in nature where answers are provided with a 4-point Likert scale response and ranged from 1-4 where 1 is considered strongly disagree and 4 is considered strongly agree. The internal consistency for the CUCEI has been measured in several studies and shown to be acceptable with Cronbach's alpha coefficients ranging from 0.70 to 0.90 (Fraser et al., 1986; Strayer, 2012).

The questions used to determine satisfaction were as follows: 1. The students look forward to coming to classes; 2. Students are dissatisfied with what is done in the class; 3. After the class, the students have a sense of satisfaction; 4. Classes are a waste of time; 5. Classes are boring; 6. Students enjoy going to this class; 7. Classes are interesting (Fraser & Treagust, 1986). Responses to statements 2, 4, and 5 were scored in the reverse manner (Fraser & Treagust, 1986). The mean value for satisfaction was recorded for each student. The internal consistency for the Satisfaction subcategory is shown to be acceptable having a Cronbach's alpha coefficient of .88 (Fraser & Treagust, 1986).

Operational Definition of Variables

Independent variable. The independent variable for Q1 and Q2 is the learning environment in a F2F instructional setting. The treatment and control group are the flipped classroom and traditional learning environment, respectively, and had a nominal level of measurement (Black, 2002; Musallam, 2010; Strayer, 2012). In the flipped classroom learning environment (treatment group), students were presented content via vodcasted lectures outside of class and interactive activities completed in class (Musallam, 2010). In the traditional lecture learning environment (control group), lectures were delivered in class and interactive activities were completed by the student outside of class.

Pre-knowledge. Pre-knowledge was considered a covariate in Q1 and Q2 and controlled for in the analysis of student achievement and satisfaction with the flipped classroom learning environments. A pretest was administered to determine the level of pre-knowledge students in the control and treatment groups prior the treatment (Musallam, 2010; Sesen & Tarhan, 2010). The pretest consisted of 27 multiple choice questions aligned with the course outcomes. Pretest scores are considered ratio and ranged from 0-100%.

Academic Motivation. Even though many researchers found that the level of academic motivation does influence achievement and students' satisfaction, studies highlighted in the literature review were conducted in a traditional classroom (Lavendar, 2005; Ning & Downing, 2012; Vansteenkiste et al., 2009). Level of student academic motivation was considered a covariate in Q1 and Q2 and controlled for in the analysis of student achievement and satisfaction with the flipped classroom compared to the traditional learning environments (Ning & Downing, 2012; Rastegar et al., 2010; Vansteenkiste et al., 2009). The level of student academic motivation was determined using the AMS-C developed by Vallerand et al. (1993) prior to the commencement of the study. This scale is designed to assess a student's academic motivation based upon Deci and Ryan's self-determination theory (Lavendar, 2005; Vallerand et al., 1993; Vansteenkiste et al., 2009). The level of academic motivation is considered ratio and was determined by the formula prescribed by Vallerand (communication, Ariane St-Louis). Academic motivation is divided into subscales that correspond with the AMS-C (Vallerand et al., 1993). The seven subscales of the AMS-C have an internal consistency ranging from .83 to .86 (Cokley, 2000).

Student achievement. Student achievement was considered a dependent variable in Q1. Measuring achievement in a class is most often determined by grades earned (Ning & Downing, 2012; Rastegar et al., 2010). To that end, both the flipped and lecture instructors administered the posttest in the form of a final exam. With regards to Q1, the determination of whether the flipped classroom instructional model affects achievement in an elective science course was achieved by the comparing the scores from control and treatment groups (Armaral & Shank, 2010; Ning & Downing, 2012; Rastegar et al., 2010). Posttest scores are considered ratio and ranged from 0-100%. The posttest consisted of identical questions as the pretest, but both the questions and answer choices were scrambled and administered approximately 16 weeks apart.

Student satisfaction. Student satisfaction with the flipped classroom learning environment was considered a dependent variable in Q2 (Strayer, 2012). To answer Q2, the level of student satisfaction was determined in the control and treatment groups (Strayer, 2012) while controlling for the level of academic motivation and pre-knowledge. Satisfaction in the flipped classroom was determined using a satisfaction survey adapted from the CUCEI questionnaire (Fraser et al., 1986; Strayer, 2012). The CUCEI was considered ordinal in nature where answers were provided with a 4-point Likert scale response and ranged from 1-4 where 1 was labeled strongly disagree and 4 labeled strongly agree. The internal consistency for the CUCEI has been measured in several studies and shown to be acceptable with Cronbach's alpha coefficients ranging from 0.70 to 0.90 (Fraser et al., 1986; Strayer, 2012).

Data Collection, Processing, and Analysis

Prior to the first day of Spring 2014 Environmental Science classes, enrolled students were sent a Welcome email from the flipped and lecture instructors through Penn College's secure email system. The email to the flipped and traditional sections was identical except for the inclusion of a flipped classroom description to students in that section (Appendix D and F). Following the Welcome email, students in both the treatment and control were sent informed consent information (Appendix E and G).

The informed consent was sent to students embedded in a link to the initial AMS-C survey using Qualtrics survey software. Prior to starting the AMS-C survey, the researcher asked students if he or she is willing to participate in the study. If the student checked the "I am willing to participate" radio button, consent was granted by the student. In a seamless progression, the researcher designed the survey in Qualtrics to direct the student to complete the AMS-C survey. When a student chose to participate in the study, he or she was asked to complete an assessment of his or her level of academic motivation using the AMS-C (Lavendar, 2005; Vallerand et al., 1993; Vansteenkiste et al., 2009).

If the student chose not to participate in the study by checking the "I am not willing to participate" radio button, the student was given the option to drop the course and email the researcher for suggestions about alternate sections of Environmental Science that are not part of the study. The student also had the option to opt out of the study after the course begins. In this case, no data was collected with respect to the one student who chose to opt out of the study.

Data collection for treatment and control groups. On the first day of class, the syllabus was reviewed with both groups and the students were informed that a pretest was to be administered during the following class meeting. The flipped instructor discussed the flipped classroom with the treatment group and demonstrated how to access and interact with the vodcasts found in the learning management system (LMS). On the second class meeting, students in both the flipped and traditional groups took a pretest to assess his or her pre-existing environmental science knowledge. To ensure non-bias during the semester, the researcher did not share results from the AMS-C survey and pretest with the flipped and lecture instructors until final course grades were entered into the Penn College grading system.

Treatment group out-of-class activities. Content knowledge was acquired outside of class for the treatment group. This content delivery was in various forms, but was primarily in the form of a vodcast. The flipped class students were directed to view a lecture vodcast linked in the LMS, read the textbook, and/or read a website.   Regardless of the content delivery, the students were asked to take notes on the vodcast lecture and/or readings. The flipped instructor reminded students that he or she can pause, stop, and rewind the vodcast as notes are taken. The flipped instructor instructed students that as notes are taken, any questions that arise should be recorded in the notes

Treatment group in-class activities. Notes were checked by the flipped instructor as the students entered the classroom. Students sat in groups of 3-4 students facing each other. The flipped instructor began by asking the students if there are any questions from the chapter lecture vodcast or readings. The flipped instructor assigned an activity that allowed students to interact with the content collaboratively. The flipped instructor roamed the room interacting with the students, answering questions, and clarifying misconceptions. The flipped instructor stopped the group discussions to clarify or answer any questions that are common for all groups. Before the end of class, each student submitted the results of the activity for a grade and be given instructions for the out-of-class activity to be completed prior to the next in-class meeting.

Control group in-class activities. The traditional class students entered class with the results from an at-home activity. After discussion and questions are addressed by the lecture instructor, this activity was collected for a homework grade. The lecture instructor gave a lecture with emphasis on the learning objectives for that lesson. The lecture instructor provided students an opportunity to ask questions as the lecture proceeded.

Control group out-of-class activities. The activities included readings, website review, or homework questions. These activities were aligned with the learning objectives that are identical to those in the treatment group and involved active learning based upon the content that was delivered via the in-class lecture.

Control and treatment group assessments. The flipped and lecture instructors administered three unit exams to the treatment and control groups throughout the semester. After the completion of all course content and prior to the final exam, students in both the treatment and control groups were sent a student satisfaction survey via the Qualtrics survey software (Appendix C). The survey consisted of questions from the CUCEI questionnaire. The researcher directed students to print the last page of the CUCEI questionnaire upon the completion. To ensure a high response rate, the students received five extra credit points on the final exam if the last confirmation page was submitted. If a student forgot to print the last page, access to the CUCEI questionnaire was granted again.

Upon completion of all course content, the flipped and lecture instructors administered a final exam consisting of 50 multiple choice and true/false questions. Embedded in the final exam were the 27 multiple choice pretest questions. The responses to these questions and percentage correct were used as the posttest for both the treatment and control groups in this study. The student used an Op-Scan form to enter the correct answers to each question. Students received three hours to complete the final exam with the embedded pretest/posttest questions. The flipped and lecture instructors processed the Op-Scan form using an optical mark read Op-Scan scanner that graded each question with respect to the correct answers. The flipped and lecture instructors entered all final exam scores into the LMS gradebook with respect to each student's name in both the treatment and control groups. The portion of the final exam that corresponded to the pretest/posttest questions were scored separately and given to the researcher.

Data processing for Q1 and Q2. The level of student academic motivation was determined using the AMS-C developed by Vallerand et al. (1993) prior to the commencement of the study. Academic motivation is divided into categories that correspond with the AMS-C (Vallerand et al., 1993). The self-determination index was determined using the SDT formula and this value was recorded next to each student's name.

On the first day of class, the flipped classroom students took a pretest to assess his or her pre-existing environmental science. The student used an Op-Scan form to enter the correct answers to each question. Students received ample time to complete the pretest. The instructors gave the Op-Scan sheets to the researcher. The researcher processed the Op-Scan form using an optical mark read Op-Scan scanner that graded each question with respect to the correct answers. After all Op-Scan forms scored, the researcher secured all pretest Op-Scan forms in a file drawer in a private, locked office until the semester was complete and the course grades are submitted. All pretest scores were recorded as a percentage correct on an Excel spreadsheet with respect to the student's name. The pretest results or the test questions were not returned to the student.

To answer Q1, students took a posttest in the form of a final exam after exposure to the treatment of the flipped classroom and traditional lecture environments. The posttest consisted of identical questions as the pretest, but both the questions and answer choices were scrambled and administered 16 weeks apart (Musallam, 2010). This helped to minimize the threat to internal validity from testing effects (Black, 2002). Similar pretest conditions as described above were conducted when administering the posttest. The flipped and lecture instructors scored the posttest questions on Op-Scan sheets and provided this score to the researcher. The researcher entered the posttest scores with respect to the student's name on the Excel spreadsheet. The posttest questions contributed to the students' final exam grade for the course.

With regard to Q2, satisfaction in both the flipped classroom and traditional learning environments was determined using a satisfaction survey adapted from the CUCEI questionnaire (Fraser et al., 1986). The CUCEI was designed to measure students' perceptions of his or her actual learning environment (Fraser & Treagust, 1986; Fraser et al., 1986; Strayer, 2012). Qualtrics survey software provided the results of the CUCEI survey for each student respondent. The researcher compiled the responses from the questions relating to the satisfaction subcategory and determined the mean satisfaction score. This mean score was recorded on an Excel spreadsheet with respect to the student's name.

Data analysis for Q1 and Q2. An Excel spreadsheet was used to record information for the both the treatment and control groups. Students' names were recorded in one column and the corresponding pretest scores, motivation (self-determination index value), posttest scores, and mean satisfaction, were recorded in separate columns for each student. Once all data were recorded, student names were replaced with the Penn College identification number to ensure anonymity.

Because achievement and satisfaction with the flipped classroom may be influenced by the individual student's level of motivation and pre-knowledge (Lavender, 2005; Ning & Downing, 2012), studying the effects of motivation on achievement and satisfaction in the flipped classroom was accomplished using Analysis of Covariance (ANCOVA). ANCOVA is a combination of multiple regression and analysis of variance (Iversen, 2004). In theory, individual characteristics like the level of motivation and pre-knowledge can be used to explain group processes (Gonzalez & Griffin, 2002). In this study, the aim of ANCOVA was to control for the group differences on the level of motivation and pre-knowledge while examining the mean differences in student achievement in the flipped classroom compared to the traditional classroom (Iverson, 2004). Ning and Downing (2012) conducted a similar study where student motivation was determined to mediate cumulative GPA with respect to the learning experience.

To analyze data collected for Q1, the individual student's posttest scores were entered into the Statistical Package for the Social Sciences (SPSS) data editor as the dependent variable. Learning environment was the independent variable, considered nominal, and was entered as a fixed factor. The results were initially analyzed to determine if the learning environment is a significant predictor for achievement. However, to answer Q1, the level of motivation and pretest scores were entered as covariates. Interpretation of the *F*-test indicated the percent of variability in achievement that can be accounted for by either or both the level of motivation and content pre-knowledge in the flipped classroom. To analyze data collected for Q2, data was entered into the SPSS data editor similarly to Q1, except the individual student's level of satisfaction was entered as the dependent variable.

Assumptions

Due to the fact that Penn College is an open-enrollment institution, the population was assumed to have a wide range of academic motivation and preparedness (Lavender, 2005). Further, students taking Environmental Science are assumed to represent the Penn College student population to a greater extent than students taking a science course required by majors in fields such as health sciences or engineering. This fact alone framed the study design as previous researchers implemented the flipped classroom learning environment with students who had an interest and career goals with a science emphasis or at a competitive university (Crouch & Mazur, 2001; Lage et al., 2000; Lasry et al., 2008; Mazur, 2009; Musallam, 2010; Strayer, 2012; Zappe et al., 2009).

Treatment and control group equivalency was assumed due to similar registration methods and the fact that students enrolled in both groups are from the same population. Students were non-randomly assigned to the treatment and control groups based upon self-enrollment in the Environmental Science course during the Spring 2014 semester. Sampling techniques used to assign the treatment group were identical to those used to assign the control group. In other words, all students enroll in sections of Environmental Science similarly.

It was assumed that all students in the treatment group interacted with the vodcast in a similar manner based upon the instructor's initial tutorial on how to interact with a vodcast. Students may have chosen to play the entire vodcast without pausing, rewinding, and taking the time and effort required to fully benefit from the recorded lesson. Other students may have spent the time and effort interacting with the vodcast as suggested by the researcher. In this situation, interaction with the vodcast could be a variable in student achievement and satisfaction with the flipped classroom.

Instructor interaction and teaching quality was assumed to be similar for both groups. The flipped and lecture instructors were not a stakeholder in this study. The flipped and lecture instructors have been teaching Environmental Science for over a decade and are the lead instructors for the course. Both instructors work collaboratively on refining and assessing course outcomes and learning objectives. Therefore, consistent, quality instruction was provided to both the control and treatment groups.

Limitations

This study was limited by factors that affected the methodology and sample. In terms of the convenience sample, a question regarding the ability to generalize the results to all non-science students at the college level may be a concern. Even though Penn College is considered an open-enrollment institution, students enroll in programs because of the applied nature of the major. The flipped classroom may better meet these learners' preferred learning environment due to the applied nature of the flipped classroom. Therefore the characteristics of the participants and the nature of the treatment may not be generalized to all non-science college students and the external validity of the study in terms of population generalization may be compromised. However, if the study was conducted at multiple higher education institutions, the internal validity of the study would be compromised (Vogt, 2005). Instructor style and experience, course outcomes, and student population are extraneous variables that could not be controlled by the researcher if the study was conducted at various colleges and universities (Vogt, 2005).

Response rates for surveys administered to Penn College students are low (T. Gregory, personal communication, March 28, 2013). To overcome this possible limitation, extra credit was used to encourage students to respond to the AMS-C and CUCEI surveys. As described in previous sections, both surveys ended with a confirmation of completion page that students printed and submitted to the instructor. Extra credits points were given on the exams if students completed the surveys. Students completed the posttest as the final exam for the course so both content-knowledge honesty and completion rates are assumed to be high.

A large effect size was reported in previous studies on the flipped classroom learning environment (Musallam, 2010; Strayer, 2012). Both Musallam (2010) and Strayer (2012) indicated that student achievement and satisfaction were significantly affected by the learning environment. G*Power *a priori* analyses were performed using a large effect size for both hypotheses 1 and 2. As a result, a minimum sample size of N = 55 was required to have an optimal chance of rejecting both hypotheses 1 and 2. The sample size was N = 49, slightly less than the 55 students required by the *a priori* analysis. This sample size may not be large enough to detect a relationship between the variables if the effect size in this study is not as large as reported by Musallam (2010) and Vansteenkiste et al. (2009). In this case, a Type II error may have occurred (Black, 2002).

Another limitation is the inability to randomly assign the groups to either the treatment or the control. Group nonequivalence could be considered a limitation to this quasi-experimental study. However, a comparison of pretest scores and student motivation was used to compare the homogeneity of students in the treatment and control groups prior to the treatment (Black, 2002; Vogt, 2005). The only difference between the control and treatment groups' learning environment is when students experience and interact with the activities (in-class versus out-of-class). Therefore, internal validity of the treatment should be high as the treatment and control groups received the similar instruction tied to the course outcomes just in different locations (Black, 2002; Vogt, 2005).

Further, a between-groups design could lead to internal validity threats such as resentful demoralization and compensatory rivalry (Black, 2002). The control or treatment group may see the other learning environment as more beneficial to their learning style. However, the students in both groups had little to no interaction. The flipped and lecture instructors reduced any possible differences in instruction in both groups as the all activities were aligned with the course and learning objectives. The main difference between the two groups was whether the content acquisition took place in the presence of the instructor.

With respect to the methodology, the absence of a pilot study used to validate and assess the pre- and posttest reliability prior to the study was a limitation. Since few flipped classroom studies are found in the literature and a non-science class such as Environmental Science has not been studied using the flipped classroom learning environment, a panel of experts was used to validate the pretest/posttest. Musallam (2010) validated the pretest/posttest used in his study in a similar manner.

Testing effects could be another limitation to the methodology. However, due to the time span of approximately 16 weeks between administering the pre- and posttest, testing effects was most likely not a significant factor that limited the results in this study. To address the limitation of testing effects, the researcher scrambled all questions and questions responses to decrease any possible testing and instrumentation effects. To limit the testing effects, the pre- and posttest contained the same questions, but the questions and response choices were scrambled on the posttest.

Instructor bias could be considered a limiting factor in this study. However, since the treatment and control groups had a different instructor, bias did not limit the results of this study. Further, learning environment preference was not an issue due to the fact that study was conducted over the course of the semester with activities aligned with the course outcomes and grading systems in both the treatment and control groups. The flipped and lecture instructors for Environmental Science have taught the course for over a decade, provides excellent instruction (C. Coppersmith, Dean, personal communication, August 5, 2013), and were not stakeholders in the results.

Similarly, the researcher was not a stakeholder in the outcome of this study. The researcher's personal or professional gains were not attributed to the outcomes of this study. The results of this study will only contribute to the application of the flipped classroom in higher educational institutions. Preference for the flipped or traditional classroom learning environment was also not a factor in outcome as the researcher only gathered the data and did not provide the instruction.

Delimitations

A quantitative, nonequivalent group quasi-experimental design was chosen for this study. There are few studies in the literature where researchers have investigated the flipped classroom instructional model. Those researchers who have provided data have not reported a significant increase in student success (Houston & Lin, 2011; Mazur, 2009; Zappe, et al., 2009; Strayer, 2012; Lage, et al., 2000, Musallam, 2010). Many who have flipped the classroom and studied the effects have only reported the flip as applied to courses that enroll students who are academically prepared (Houston & Lin, 2011; Mazur, 2009; Zappe et al., 2009; Strayer, 2012; Lage et al., 2000; Musallam, 2010). The flipped classroom instructional model has not been studied in an elective science class at an open-enrollment institution. Because of the lack of empirical evidence about the flipped classroom environment, it was determined that a quantitative approach was better suited to provide numerical data to compare student achievement and satisfaction with the flipped classroom and traditional lecture learning environments.

Motivation and pre-knowledge were considered covariates in both research questions. When mining the literature on the flipped classroom and constructivist learning environments, it appeared that most studies included students who could be perceived as having a higher level of self-determination and academically prepared. Further, flipped classroom researchers did not consider level of motivation as a covariate (Lage et al., 2000; Mazur, 2009; Musallam, 2010; Strayer, 2012; Zappe et al., 2009). Most constructivist learning researchers considered motivation levels and self-determination as the dependent variable and considered the change of motivation or self-determination in a constructivist learning environment (Araz & Sungar, 2007; Baeten et al., 2010; Hill, 2013; Wijnia et al., 2011). Only a few researchers considered the level of motivation as a covariate, but these studies were conducted in a traditional lecture learning environment (Co, 2010; Liu et al, 2012; Ning & Downing, 2012; Rastegar et al., 2010). Individual characteristics could influence achievement and satisfaction in a student-centered learning environment (Baeten et al., 2013; Baeten et al., 2010). To this end, the purpose of this study was to investigate student achievement and satisfaction with the flipped classroom learning environment while considering the level of motivation and pre-knowledge. The research questions reflect this purpose.

Students who enrolled in Environmental Science at Penn College did so out of his or her own volition. Environmental Science is not a required course for any major at Penn College. Therefore, students taking this course may not see the application of the content to his or her future profession. Baeten et al. (2010) suggested that students are more intrinsically motivated (have a higher level of self-determination) to learn material if it is applicable to a future profession. However, students may have chosen the course out of personal interest and could have been more motivated to learn the material (Baeten et al., 2010; Baeten et al., 2013; Deci & Ryan, 2008a; Nie & Lau, 2010; Niemiec &

Ryan, 2009). To this end, students taking Environmental Science were chosen as the subjects of this study due to the possible wide range of motivation levels and academic interests.

Additionally, the Penn College student population was chosen for this study not only due convenience for the researcher, but also because of Penn College's open-enrollment policy. The student population at Penn College represents the population in rural Pennsylvania and students who seek degrees in technical fields to a greater extent than those students seeking degrees at competitive universities (Penn College, 2014). The population for this study was more aligned with the average student (Lavender, 2005). The results of this study could be generalizable to students who are not as academically prepared or motivated as those who attend competitive colleges or universities.

Ethical Assurances

Institutional Review Board (IRB) approval was sought and approved prior to the start of the study and collection of data. Additionally, approval was obtained for this study from Penn College administration (Appendix H). The participants were college students 18 years old and above. The college students enrolled in the sections based upon his or her class schedule. Students were not informed about the study prior to registration however the students in the flipped classrooms were sent a Welcome email with a description of the flipped classroom (Appendix D). Students in both the control and treatment groups were sent an informed consent (Appendix E and G) by the Qualtrics software system using the students' Penn College email address. Upon agreeing to participate in the study, students in both groups were asked to complete the AMS-C survey (Appendix A).

On the first day of class, students in the flipped classroom were given a short in-class tutorial in how to interact and learn from a vodcast. The personal risks and deception to students who participate in this study were minimal to none. Students in the flipped classroom participated in activities similar to those that were assigned in the traditional lecture learning environment. The main difference between the treatment and the control learning environments was whether knowledge acquisition took place outside of class or with the instructor in class. Based upon the Belmont Report (1979), three basic ethical principles- beneficence, autonomy, and justice were considered.

According to Cozby (2009), the principle of beneficence refers to the “need for research to maximize benefits and minimize any possible harmful effects of participation” (p. 39). In this study, the risks were non-existent to minimal. Students in the flipped classroom received similar instruction as those who were enrolled in the control learning environment. Students were given the opportunity to enroll in another elective science course or another section of Environmental Science as well as opt out of the study at any point. If the flipped classroom instructor determined that the flipped classroom learning environment negatively impacted student grades, the flipped classroom course grades would have adjusted the grades to align with the traditional lecture course grades. The research was designed to study the potential benefits of the application of the flipped classroom teaching methodology as applied to elective science courses at open-enrollment colleges. Therefore, “knowledge gained through the research might improve future educational practices” (Cozby, 2009, p. 39).

There was no psychological risk, physical harm, or stress related to this study.

The researcher investigated students in learning environments therefore students' individual characteristics were not compromised. Privacy and confidentiality were maintained through anonymous, coded surveys, and aggregated data. Before the first day of class each student was sent informed consent information. The student was informed about the "purpose of the study, the risks and benefits of participation, and their rights to refuse or terminate participation in the study" (Cozby, 2009, p. 42).

Students were given autonomy for this decision by selecting to participate or not participate using a radio button. If a student chose to take part in the study the student was directed to select the "I choose not to participate in this study" radio button below the informed consent. If a student did not want to take part in the study, he or she was assisted in finding an alternate section of Environmental Science or science elective course. If the student chose to participate in the study through the informed consent, the AMS-C survey was administered. To remove any bias toward students with high levels of motivation and pre-knowledge, the resulting level of motivation and pretest scores were not disclosed to the instructor until after the course completion.

There was no student enrolled in this course that lacked the ability to make free and informed decisions about participation. If there was a student with special needs that may have cognitive impairments, the researcher would have worked with Disability Services to make the necessary accommodations. Prior to the start of class, the instructor provided an overview of the flipped classroom to the treatment group, but did not specifically inform the students about the hypotheses. Results from the AMS-C were provided upon student request. The student was informed that his or her level of academic motivation would not be associated in any way with an identifier and the identity key would be destroyed after the data are compiled.

Summary

Due to the nature of the research questions, a nonequivalent between-groups design was conducted. Environmental Science is a popular science course for Penn College students who need to fulfill the science elective requirement for graduation. Different instructors taught one section of Environmental Science offered during the time of study and each section was designated as the control and treatment group. Sections of Environmental Science were capped at 30 enrollees. For this reason, a maximum sample size of 60 students was considered, but only $N = 55$ were required per *a priori* analysis. However, there were fewer than $n = 35$ students in each section. The independent variable for both research questions in this study was the learning environment. The treatment learning environment was the flipped classroom and the control was the traditional lecture learning environment.

For Q1, the posttest scores were considered the dependent variable and the pretest scores and the level of student motivation were considered covariates. For Q2, student satisfaction was the dependent variable and the pretest scores and the level of student motivation were considered covariates. Data from both research questions was analyzed using an ANCOVA analysis. An ANCOVA analysis was used to analyze the posttest score and student satisfaction mean differences in the treatment and control groups while controlling for level of motivation and pre-knowledge.

Qualtrics survey software was used to administer the informed consent, AMS-C, and CUCEI surveys. Pretest scores, AMS-C, and CUCEI results were not disclosed to the instructor until after the course final grades were entered. Posttest questions were embedded into the final exam and the responses part of the final exam grade for the course. Once the pretest scores, AMS-C and CUCEI results, and posttest were entered into an Excel spreadsheet with the corresponding student name, all student names were replaced with the Penn College student identification number. All data analysis was conducted using SPSS software.

Due to the nature of using human subjects for this study, IRB approval was sought and approved prior to conducting and collecting data. Participants in the study were informed prior to the commencement of the semester, given the option to not participate, and treated in an unbiased manner by the researcher. There was minimal to no risk for participants in this study.

Chapter 4: Findings

The purpose of this quantitative study was to investigate the constructivist learning theory by comparing the flipped classroom learning environment with the traditional lecture learning environment. A comparison was made using posttest scores and student satisfaction with both instructional models, while considering the level of student academic motivation and pre-knowledge amongst non-science students taking an elective science course at an open-enrollment college. The dependent variables that measured achievement and satisfaction were posttest results and the satisfaction construct from the CUCEI survey. Covariates that measured academic motivation and pre-knowledge were results from the AMS-C tool and the pretest results. The two independent variables that measured the learning environment were the lecture classroom and the flipped classroom.

Despite the attention that the flipped or inverted classroom has been getting in mainstream media and educational blogs (WSJ, 2012; Young, 2012), researchers have been uncertain as to whether the flipped classroom environment increases student achievement (Hao, 2013; Merrill, 2008; Vos et al., 2010; Zappe et al., 2009) and student satisfaction within the learning environment (Lancaster, 2013; Strayer, 2012; Zappe et al., 2009) for students with varying academic preparedness and motivation levels. Student intrinsic motivation increases in a constructivist learning environment, but researchers have not indicated if student motivation mediates achievement or satisfaction in a constructivist learning environment such as the flipped classroom (Baeten et al., 2010; Sesen & Tarhan, 2010; Vansteenkiste et al., 2009; Vos et al., 2010).

Data were gathered using two instruments. Academic motivation was administered near the beginning of the semester. The CUCEI survey was administered at the end of the semester. Data were collected from 56 students in both the lecture and flipped classroom. However, seven students did not complete both surveys and were not included in the data set. The sample size of 49 students did not meet *a prior* analysis requirement of 55 participants.

Chapter 4 begins with an overview of the descriptive statistics and the five assumptions that allow for the use of ANCOVA. These five assumptions are discussed and the corresponding statistical information presented as text, in tables, and graphically. After addressing the five assumptions that allow the use of ANCOVA analysis, the results of the ANCOVA for each hypothesis are presented based on descriptive, reliability, correlation, and regression statistics. An evaluation of the findings with respect to the constructivist theory follows the presentation of the results. The chapter concludes with a summary of the results. Data used in this analysis was derived from 49 students in two different learning environments. Inferential analyses were performed using SPSS v20.0 software. All analyses were tested at the 95% ($p < .05$) significance level.

Results

This section begins with a summary of the descriptive statistics and a restatement of the reliability measurements. The analysis of covariance (ANCOVA) requires several assumptions to be met upon analysis. Five assumptions will be addressed that allow for the use of ANCOVA. The summary of the five assumptions for the use of ANCOVA will be followed by the ANCOVA analyses for each research question and hypothesis.

Descriptive statistics. Descriptive statistics are used to provide general information about the variables used in a study (Breukelen, 2010). The dependent variables in this study include posttest scores and level of satisfaction. The covariates in this study include pretest scores and motivation level derived from the self-determination index resulting from responses from the AMS-C survey (Vallerand et al., 1993). The independent variables of learning environment were nominal variables entered as lecture = 0 and flipped = 1. The pretest scores and motivation level covariates and posttest and satisfaction independent variables are all considered continuous. Table 1 summarizes the descriptive statistics for the variables in this study.

Table 1

Descriptive Statistics for Dependent and Covariate Variables

Variable	*N*	Mean	*SD*	Skewness	Kurtosis
Posttest	49	72.42	12.86	-.062	-.922
Satisfaction	49	3.122	.331	.345	.429
Pretest	49	60.65	12.84	-.345	-.739
Motivation	49	28.75	7.99	-.587	-.269

Note: *SD*= standard deviation

Skewness describes the distribution's shape or symmetry (Breukelen, 2010; Iversen, 2004). The posttest scores, satisfaction, pretest scores indicate that the data are approximately symmetrical. Motivation skewness is moderately skewed. Kurtosis values tell a researcher about the height of the distribution peak (Breukelen, 2010; Iversen, 2004). Normally distributed data have a kurtosis of 3. Any values less than 3 indicate a distribution of data that is centrally distributed with few tails (Breukelen, 2010; Iversen, 2004). The kurtosis values for the variables are all less than 3.

Reliability measurements. The tools used in this study included the CUCEI and

AMS-C surveys. The CUCEI responses measured satisfaction with the actual classroom environment. The internal consistency for the CUCEI has been measured in several studies and shown to be acceptable with Cronbach's alpha coefficients ranging from 0.70 to 0.90 (Fraser et al., 1986; Strayer, 2012). The mean value for satisfaction was recorded for each student. The internal consistency for the Satisfaction subcategory is shown to be acceptable having a Cronbach's alpha coefficient of 0.88 (Fraser & Treagust, 1986).

Academic motivation is divided into categories that correspond with the AMS-C (Vallerand et al., 1993). These include: 1. Intrinsic motivation- to know; 2. Intrinsic motivation- toward accomplishment; 3. Intrinsic motivation- to experience stimulation; 4. Extrinsic motivation- identified; 5. Extrinsic motivation- interjected; 6. Extrinsic motivation- external regulation; and 7. Amotivation. The seven subscales of the AMS-C have an internal consistency ranging from .83 to .86 (Cokley, 2000). To determine the motivation for each student, the categories of motivation were combined into one self-determination index as prescribed by authors of the AMS-C survey (A. St-Louis, personal communication, February 7, 2014). The formula used to determine this self-determination index (motivation) is as follows: 2((know+acc+stim/3)) + iden - ((intro+reg/2) + 2amo) = self-determination index where know= intrinsic motivation to know, acc= intrinsic motivation to accomplishments, stim= intrinsic motivation to experience stimulation, iden= identification; intro= introjected, regulation, reg= external regulation, and amo= amotivation (A. St-Louis, personal communication, February 7, 2014).

Assumptions. To answer the research questions in this study, the covariates of motivation and pretest scores are included in the model analysis of variance. This analysis is considered an ANCOVA which combines ANOVA with regression analysis (Breukelen, 2010; Iversen, 2004). There are several assumptions that need to be met in order to perform an ANCOVA analysis (Breukelen, 2010). These assumptions include (a), absence of data, (b) the assumption of normality, (c) the assumption of linearity, (d) the assumption of homogeneity of regression slopes, (e) the assumption of homogeneity of variance, and (f) the existence of an interaction effect. These assumptions will be discussed in this section.

The class size for both the lecture and flipped class were limited to 30 students; five less than anticipated. Of the 30 students in the flipped class, five did not complete both surveys and two withdrew from the course. These factors brought the total sample size for the flipped class to $n = 23$. Of the 30 students in the lecture class, one student did not complete both surveys and three withdrew from the course. All withdrawals were due to class attendance issues (R. Cooley and V. Ciavarella, personal communication, May 9, 2014). These factors brought the total sample size for the lecture class to $n = 26$. The *a prior* analysis indicated that a sample size of $N = 55$ would be required to detect differences in the learning environment if the effect size was large. If the effect size was medium to low, the sample size would need to be $N > 100$. The sample size ($N = 49$) was lower than the required size of $N = 55$ and was 11% less than the required size needed with a high effect size. Although the absence of data compromised the validity of the ANCOVA analysis, analysis of the data continued to determine if any possible differences could be detected despite the small sample size.

The assumption of normality was performed using SPSS software that tested the normal distribution of the data for both independent variables and covariates. Since the samples size was less than $N = 50$, the Shapiro-Wilk outcome was considered (Breukelen, 2010; Iversen, 2004). If the variables are normally distributed, the Shapiro-Wilk significance test should be greater than the alpha level of .05 (Breukelen, 2010; Iversen, 2004). The Shapiro-Wilk significance test indicated that all variables were normally distributed except motivation ($p = .050$). The Shapiro-Wilk significance test for posttest scores, satisfaction, and pretest scores indicated that the data came from a normally distributed population, therefore the assumption of normality was not violated.

The assumption of linearity was performed using SPSS software that tested the linear relationship between the dependent variables (posttest score and satisfaction) and the covariates (motivation and pretest scores). The scatterplot output (Appendix I) with respect to each dependent variable and covariate revealed a linear relationship between both dependent variables and each covariate. Plot 1 indicates a strong, positive linear relationship between the posttest and pretest scores in the flipped class ($R^2 = .215$) and the lecture class ($R^2 = .356$). Plot 2 shows a strong positive linear relationship between posttest scores and motivation for the flipped class group ($R^2 = .174$), but a weak, negative linear relationship for the lecture class group ($R^2 = .033$). The linear relationship between pretest scores and satisfaction is illustrated in Plot 3. Plot 3 shows a positive weak linear relationship for the flipped class group ($R^2 = .095$), but a weak, negative linear relationship for the lecture class group ($R^2 = .005$). Plot 4 illustrates a positive, linear relationship between motivation and satisfaction in both the flipped class ($R^2 = .023$) and the lecture class ($R^2 = .060$).

Next, the assumption of homogeneity of regressions was tested. To test to see if there is a statistically significant interaction between the learning environment and the covariates with respect to posttest scores, the data was analyzed using the Univariate General Linear Model (GLM) procedure. The significance level was set to $\alpha = .05$ and if the interaction is significant ($p > .05$), then the assumption of linearity is not violated.

Significance levels above .05 indicated that the assumption of homogeneity is not violated. The interaction between the pretest and posttest scores ($p = .677$) have a p-value > .05. Likewise the interaction between motivation ($p = .053$) and the posttest scores also have a p-value > .05. These values support the scatterplot data that the lecture and flipped class groups are similar in the slopes. Table 2 presents the statistical values for the F statistic, associated p-value, R squared correlation coefficient, and the partial eta-squared statistic for the between-subjects effects of the covariates with respect to the posttest score dependent variable.

Table 2

Interaction of the Covariates and Posttest Scores as the Dependent Variable

Covariate Variable	F	p	R^2	R^2 *(adjusted)*	η^2
Pretest	.176	.677	.317	.272	.004
Motivation	3.966	.053	.095	.034	.081

Note: $p < 0.5$ is considered significant

The interaction between the pretest ($p = .199$) and satisfaction have a p-value > .05. The interaction between motivation ($p = 1.00$) and satisfaction also have a p-value > .05. Significance levels above .05 indicate that the assumption of homogeneity is not violated. These values support the scatterplot data that the lecture and flipped class groups are similar in the slopes. Table 3 presents the statistical values for the F statistic, associated p-value, R squared correlation coefficient, and the partial eta-squared statistic for the between-subjects effects for the covariates and the satisfaction dependent variable.

Table 3

Interaction of the Covariates and Satisfaction as the Dependent Variable

Variable	F	p	R^2	R^2 *(adjusted)*	η^2
Pretest	1.703	.199	.050	-.013	.036
Motivation	.000	1.00	.055	-.008	.000

Note: $p < 0.5$ is considered significant

The assumptions of (a) the assumption of normality, (b) the assumption of linearity, (c) the assumption of homogeneity of regression slopes, (d) the assumption of homogeneity of variance, and (e) the existence of an interaction effect were met. The required sample of $N = 55$ was not met due to absence of data and student mortality. Even though sample size was not met, ANCOVA analysis was used to analyze the data for each research question. The findings from this analysis are described below.

ANCOVA results for research question one. The following research question and hypotheses were addressed in a science course intended for non-science major students at the open-enrollment, technical college studied.

Q1. After controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college?

H1$_0$: There is no difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in science knowledge and academic motivation.

H1$_a$: There is a difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in environmental science knowledge and academic motivation.

Analysis of hypothesis one. A sample size of N = 49 were included in the analysis of covariance. The mean values prior to adjusting for the effect of pretest scores and motivation levels for the lecture group was M = 71.00 and the flipped class M = 74.04. An ANCOVA statistical analysis was performed using SPSS software where the posttest scores were entered as the dependent variable, the learning environment as the fixed factor, and the pretest scores and motivation level as the covariates. The learning environment is a nominal variable and coded as 0 = lecture and 1 = flipped. A full-factorial model was used to provide statistical information for the mean scores for the lecture and flipped classroom groups adjusted for the covariates.

Levene's test of equality of error variances revealed that the assumption of homogeneity was not violated (p = .101). However, the ANCOVA results revealed no main effects of the learning environment, $F(1,45) = .091$, p = .765, with $R^2 = .319$ (adjusted $R^2 = .274$) on posttest scores after controlling for pretest scores and motivation. The effect size of the independent variable on the dependent variables was low (η_p^2 = .002) indicating that this difference would not be likely in the population at-large. The observed power for this analysis was also found to be low (.060). The adjusted R^2 value of .274 indicated that 27.4% of the variability in the dependent variable of posttest score was predicted by the learning environment. The adjusted means for the lecture group was M = 72.91, 95% CI [68.398, 77.426] and the flipped class M = 71.882, 95% CI [67.057, 76.707].

Examining each covariate independently with respect to the posttest score revealed no main effects for the motivation level, $F(1,45) = .290$, $p = .593$. The level of motivation should not have been included as a covariate in the analysis as it did not have an effect on the posttest scores in either learning environment. However, the pretest scores did reveal significant interaction with the posttest scores, $F(1,45) = 20.124$, $p < .0001$. The effect size of the pretest variable on the posttest score was high ($\eta_p^2 = .309$) indicating that this difference would likely be found in the population at-large. In other words, about 30.9% of the variance in the posttest score can be explained by the pretest score and not the learning environment. The observed power for this analysis was found to be low (.992). Therefore, the pretest score should have been included as a covariate as it influenced the posttest scores and may have had a negative effect in the ability to see the difference in learning environments on posttest scores.

The null hypothesis for research question one was not rejected. As a result, the alternate hypothesis for research question one was not supported by this data. Therefore, considering the data provided, the answer to research question is that there is no difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college.

ANCOVA results for research question two. The following research question and hypotheses were addressed in a science course intended for non-science major students at the open-enrollment, technical college studied.

Q2. After controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in satisfaction between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college?

H2o. There is no difference in satisfaction with environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in science knowledge and academic motivation.

H2a. There is a difference in satisfaction with environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college, after controlling for pretest in environmental science knowledge and academic motivation.

Analysis of hypothesis two. A sample size of $N = 49$ were included in the analysis of covariance. The satisfaction means prior to adjusting for the effect of pretest scores and motivation levels for the lecture group was $M = 3.15$ and the flipped class $M = 3.08$. An ANCOVA statistical analysis was performed using SPSS software where the levels of satisfaction were entered as the dependent variable, the learning environment as the fixed factor, and the pretest scores and motivation level as the covariates. The learning environment is a nominal variable and coded as 0 = lecture and 1 = flipped. A full-factorial model was used to provide statistical information for the mean satisfaction scores for the lecture and flipped classroom groups adjusted for the covariates.

Levene's test of equality of error variances revealed that the assumption of homogeneity was not violated ($p = .320$). However, the ANCOVA results revealed no main effects of the learning environment, $F(1,45) = 1.561$, $p = .218$, with $R^2 = .065$ (adjusted $R^2 = .002$) on student satisfaction when controlling for pretest scores and motivation. The effect size of the independent variable on the dependent variable was low ($\eta_p^2 = .034$) indicating that this difference would not likely be found in the population at-large. The observed power for this analysis was also found to be low (.231). The adjusted R^2 value of .002 indicated that 2.0% of the variability in the dependent variable of satisfaction was predicted by the learning environment. The adjusted means for the lecture group was $M = 3.183$, 95% CI [3.046, 3.319] and the flipped class $M = 3.054$, 95% CI [2.908, 3.200].

Examining each covariate independently with respect to the level of satisfaction revealed no main effects from the motivation level, $F(1,45) = 2.438$, $p = .125$. The level of motivation should not have been included as a covariate in the analysis as it did not have an effect on the satisfaction in either learning environment. Likewise, the pretest scores did not reveal significant interaction with satisfaction, $F(1,45) = .448$, $p = .507$. The effect sizes of the pretest variable ($\eta_p^2 = .010$) and motivation ($\eta_p^2 = .051$) on the satisfaction score were found to be low indicating that this difference would not likely be found in the population at-large. In other words, about less than 1.0% and 5.0% of the variance in satisfaction can be explained by the pretest score and motivation, respectively, and not the learning environment. The observed power for both variables was also found to be low with the observed power pretest = .100 and observed power motivation = .333. Therefore, the pretest score and motivation should not have been included as a covariate as it did not influence the satisfaction in the learning environment.

The null hypothesis for research question two was not rejected. As a result, the alternate hypothesis for research question two was not supported by this data. Therefore, considering the data provided, the answer to research question two is that there is no difference in satisfaction in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college.

Summary of ANCOVA results for research questions one and two. Table 4 summarizes the statistical findings for the ANCOVA analyses for research questions one and two. Neither null hypothesis one or two was rejected with respect to the data provided by this study.

Table 4

Summary of Inferential Statistics for ANCOVA Analysis with Covariates of Pretest and Motivation on Dependent Variables

Dependent Variable	*F*	*p*	R^2	R^2 *(adjusted)*	*Levene's Test p value*
Posttest score	.091	.765	.319	.274	.101
Satisfaction	1.561	.218	.065	.002	.320

Note: $p < 0.5$ is considered significant

Evaluation of Findings

The evaluation of the findings from this study will be discussed in this section. The discussion begins with an evaluation of the statistical information regarding the influence of the covariates on the dependent variables. The statistical information from this study will be compared to those findings from the literature that relates motivation and pre-knowledge to achievement and satisfaction. Following the discussion of the covariate influence on the dependent variables, the evaluation of the ANCOVA data will be outlined. These findings compared the traditional and flipped classroom in terms of achievement and satisfaction while controlling for motivation and pre-knowledge. The evaluation of these findings helped answer research questions one and two. The information from the ANCOVA analysis from this study will be compared to the findings from the literature that focused on the flipped classroom learning environment.

Covariate influence on dependent variables. Upon examination of the achievement dependent variable, motivation did not significantly affect achievement ($F(1,45) = .290$, $p = .593$). This finding was not aligned with the literature where researchers found that the level of motivation significantly affected achievement (Kettle, 2013; Niemic & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009). However, the pre-knowledge did significantly affect achievement ($F(1,45) = 20.124$, $p < .0001$), but it was not dependent on the learning environment. This finding was aligned with the literature that considered student pre-knowledge as a variable that influenced achievement in a traditional learning environment (Baeten et al., 2010; Lopez-Perez et al., 2011; Marchand & Gutierrez, 2011; Niemiec & Ryan, 2009; Ning & Downing, 2012).

Considering the satisfaction dependent variable, motivation did not significantly influence satisfaction ($F(1,45) = 2.438$, $p = .125$). Likewise, the findings indicated that pretest knowledge did not significantly influence satisfaction ($F(1,45) = .448$, $p = .507$). These findings were not aligned with the literature where motivation was found to significantly influence satisfaction (Hao, 2013; Kettle, 2013; Niemic & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009). However, many of these studies were conducted in a traditional lecture environment (Niemic & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009).

Those researchers who investigated motivation in a flipped classroom learning environment found that students who had more self-regulation and high quality motivation were more satisfied with the flipped classroom (Hao, 2013) and were more successful (Kettle, 2013). With respect to this study, the statistical results indicated that motivation did not significantly influence achievement or satisfaction regardless of the learning environment. The ability to detect this difference may be due to the small sample size. This would result in a Type II error which is the failure to reject a false null hypothesis (Black, 2002).

Evaluation of results from ANCOVA. The findings from this study did not reject null hypotheses one and two. Null hypothesis one was not rejected as findings indicated that there was no significant difference, $F(1,45) = .091$, $p = .765$, in the lecture and flip class achievement when controlling for pre-knowledge and motivation. The findings from this study indicated that pre-knowledge and motivation did not influence achievement in a flipped classroom compared to the traditional lecture classroom. Similarly, null hypothesis two was not rejected as findings indicated that there was no significant difference, $F(1,45) = 1.561$, $p = .218$, in the lecture and flipped classroom satisfaction when controlling for pre-knowledge and motivation. The findings from this study indicated that pre-knowledge and motivation did not influence satisfaction in a flipped classroom compared to the traditional lecture classroom.

These findings are inconclusive in that no statistical difference was found in the achievement and satisfaction outcomes between the lecture and flipped classroom learning environments. Several researchers report conflicting results regarding the effects of student motivation and pre-knowledge on achievement and satisfaction. Researchers proposed that not all learners are prepared academically or have the motivation to perform successfully in a constructivist learning environment like the flipped classroom (Kirschner et al., 2006; Lavasani & Ejei, 2011; Liu et al., 2012). Other researchers found that motivation and pre-knowledge influenced student achievement and satisfaction in a constructivist learning environment (Hao, 2013; Kettle, 2013; Niemic & Ryan, 2009; Ning & Downing, 2012; Vansteenkiste et al., 2009).

With respect to studies on the flipped classroom, researchers described findings similar to this study in that student satisfaction and academic achievement did not increase significantly in a flipped classroom learning environment (Atteberry, 2013; Zappe et al., 2009). Specifically, students were less satisfied with how the structure of the flipped classroom oriented the student to the learning tasks in the course (Berrett, 2012; Lage et al., 2000; Missildine, Fountain, Summers, & Gosselin, 2013; Strayer, 2012; Zappe et al., 2009). The findings from this study are aligned with the literature (Berrett, 2012; Lage et al., 2000; Missildine et al., 2013; Strayer, 2012; Zappe et al., 2009) and the most recent preliminary report from a National Science Foundation (NSF) grant (Atteberry, 2013). However, most recently two researchers reported that quality of motivation influences satisfaction with the flipped class where achievement was not considered (Hao, 2013; Kettle, 2013). Again, with regards to this study, a Type II error may have occurred due to the small sample size (Black, 2002).

Summary

The null hypotheses for research questions one and two were not rejected. The alternate hypotheses for research questions one and two were not supported by the data from this investigation. Therefore, considering the data provided the answer to research question one is that there is no difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college. Likewise, considering the data provided the answer to research question two is that there is no difference in satisfaction in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college.

Four of the five assumptions for ANCOVA analysis were met according to the statistical findings for the analysis of each assumption. These assumptions include (a), absence of data, (b) the assumption of normality, (c) the assumption of linearity, (d) the assumption of homogeneity of regression slopes, (e) the assumption of homogeneity of variance, and (f) the existence of an interaction effect. The assumption of absence of data was not met due to the small sample size. Motivation levels were determined using the self-determination index that is calculated using the means of each of the seven AMS-C subcategories. Motivation did not appear to be normally distributed and had a Shapiro-Wilk's value of .050.

Researchers indicated that motivation influenced student achievement in a traditional classroom. The findings from this study were not aligned with literature with respect to motivation and achievement. However, researchers indicated that pre-knowledge did significantly affect achievement. The findings from this study were aligned with the literature with respect to pre-knowledge and achievement. Considering student satisfaction with the learning environment, researchers suggested motivation and pre-knowledge significantly influenced satisfaction with the learning environment. The findings from this study were not aligned with the literature as neither motivation nor pre-knowledge was found to affect achievement or satisfaction with the learning environment.

Previous studies that investigated the effects of motivation and pre-knowledge on achievement and satisfaction were conducted in a traditional learning environment. Researchers that investigated the flipped classroom found mixed results with respect to achievement and satisfaction. Very few researchers indicated significant increases in student achievement in the flipped classroom compared to the traditional learning environment. Several researchers reported mixed results with regards to student satisfaction in the flipped classroom learning environment compared to the traditional learning environment. The findings in this study were aligned with most recent flipped classroom studies that found no significant increases in student achievement and satisfaction with the flipped classroom learning environment.

Chapter 5: Implications, Recommendations, and Conclusions

The flipped classroom has gained momentum as a learning environment that supports the trend for teaching 21st century learners by providing an active, student-centered environment through the use of modern technology (Hao, 2014; Lancaster, 2013; Missildine et al., 2013; Smith, 2013). However, researchers have been uncertain as to whether the flipped classroom environment increases student achievement and learning (Atteberry, 2013; Merrill, 2008; Vos et al., 2010; Zappe et al., 2009) and student satisfaction with the learning environment (Missildine et al., 2013; Strayer, 2012; Zappe et al., 2009) for students with varying academic preparedness and motivation levels (Hao, 2014; Kettle, 2013).

The purpose of this quantitative study was to investigate the constructivist learning theory by comparing the flipped classroom learning environment with the traditional lecture learning environment. A comparison was made using posttest scores and student satisfaction with both instructional models, while considering the level of student academic motivation and pre-knowledge amongst non-science students taking an elective science course at an open-enrollment college. A quasi-experimental quantitative design method was implemented using data from pretests, posttests, AMS-C and CUCEI surveys to compare a lecture and flipped classroom learning environment.

Ethical issues were not identified in this study. The AMS-survey or pretest results were not shared with the instructors until after grades were entered. All results were kept in a locked file drawer in the researcher’s private office. Data were saved on a secured computer. This chapter provides an overview of the implications of the findings with respect to both research questions and corresponding hypotheses. Recommendations for future research are discussed followed by overarching conclusions and summary of this chapter.

Implications

This section will begin with the limitations that affected both research questions in this study. Following the discussion of the overarching limitations to the study, the limitations, implications of the findings, and how these results are aligned with the literature with respect to each research question will be outlined.

Limitations as applied to both research questions. Implications of this study may have been distorted by limitations discussed in Chapter 3 that affected both research questions. The maximum sample size for this study was limited to the number of seats in a physical classroom during the Spring 2014 semester ($N = 60$). In addition, factors such as subject mortality (7% of the students in both sections withdrew from the course) and low survey response rates by Penn College students, lowered the sample size to $N = 49$. According to Musallam (2010) and Vansteenkiste et al. (2009), the learning environment had a large effect size on the outcomes. As a consequence, G*Power *a priori* analyses were performed using a large effect size for both hypotheses 1 and 2. As a result, a minimum sample size of $N = 55$ was required to have an optimal chance of rejecting both hypotheses 1 and 2. Since the sample size for this study was less than $N = 55$, the sample size may not have been large enough to detect a relationship between the variables if the effect size in this study was not as large as reported by Musallam (2010) and Vansteenkiste et al. (2009). In this case, a Type II error may have occurred (Black, 2002).

Another potential limitation of this study that may have affected the findings for both research questions is the difference in instruction between the two instructors of the treatment and control groups. Even though both instructors provided activities that were aligned with the course outcomes and learning objectives, teaching style and type of activity may have influenced student achievement and satisfaction (Kettle, 2013). The classroom instructor is an important consideration when conducting learning environment studies (Kettle, 2013; Strayer, 2012; Wijnia et al., 2011). Both instructors in this study had experience teaching environmental science, but neither had experience with the implementation of the flipped classroom. Flipped classroom experts suggested that flipped classroom studies not be conducted with “first-time flippers” (Jaschik & Lederman, 2014). The flipped classroom learning environment becomes more effective as the instructor’s experience increases (Bates & Galloway, 2012; Bergmann & Sams, 2012; Kettle, 2013; Lancaster, 2013). A study conducted with an instructor experienced in flipped classroom methodologies may have produced a difference in achievement and student satisfaction.

The limitation of accurate student responses may have affected both research questions. Academic motivation and pre-knowledge were covariates for both research questions. The responses to the AMS-C survey may not have accurately measured student motivation. It is difficult to elicit candid responses from Penn College students (T. Gregory, personal communication, March 28, 2013). In addition, the AMS-C measured students’ motivation to go to college as opposed to motivation to learn science. Pre-knowledge was based on students’ scores on the pretest. The pretest/posttest was developed by the Environmental Science instructors in this study. The absence of a pilot study used to validate and assess the pre- and posttest reliability prior to the study limits the reliability of this tool. The pretest may not have correctly measured the pre-knowledge covariate.

The following discussion is focused on the limitations and implications of each specific research questions and corresponding hypotheses. The findings relative to each question and how these findings align with the literature review in Chapter 2 are outlined. The subsections related to each research question will describe how the results from this study address the overall problem that is addressed in this study.

Research question one. Research question one was, after controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college? Based on the findings from this study, the answer to research question one is that there is no difference in achievement in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college.

Limitations, implications, and results for research question one. In addition to the limitations described above for both research questions in this study, the absence of a pilot study used to validate and assess the pre- and posttest reliability prior to the study limits the reliability of this tool. This limitation is specific to research question one with respect to the dependent variable, achievement. Even though the course instructors developed the questions used on the pre- and posttest, the validity may not be as strong as a standardized Environmental Science test. Therefore, the posttest may have impacted the true measure of achievement.

The results from the ANCOVA revealed no main effects of the combined covariates, pretest scores and motivation levels, with respect to the independent variable, the learning environment, on posttest scores. After controlling for pretest scores and motivation, the lecture class posttest scores was slightly higher, but not significantly higher (p = .950) than the flipped class posttest scores. The purpose of this study was to investigate the constructivist theory by comparing the flipped classroom and traditional learning environments. The findings in this investigation did not reject the null hypothesis associated with research question one. The significance of these findings implies that there is no difference in student achievement in the flipped classroom and traditional learning environments.

The few studies that investigated student achievement in a flipped classroom, researchers provided evidence of significant student gains in learning outcomes (Amaral & Shank, 2010; Bates & Galloway, 2012; Missildine et al., 2013; Musallam, 2010). However, to date, most research on the flipped classroom does not investigate student characteristics such as pre-knowledge and motivation with respect to posttest scores. In addition, there are no studies involving the flipped classroom at an open-enrollment college with non-science majors. Results of this study indicate that student achievement at an open-enrollment college do not differ with respect to learning environment. These findings are aligned with a preliminary report by four professors at Harvey Mudd College (Atteberry, 2013). The Harvey Mudd researchers found “no statistical difference” in student learning outcomes (Atteberry, 2013, para. 11). This dissertation adds to the limited findings on achievement in the flipped classroom compared to the traditional lecture as well as research involving students at an open-enrollment college.

Research question two. Research question two was, after controlling for pretest scores in environmental science and academic motivation for students, what difference, if any, is there in satisfaction between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college? Based on the findings from this study, the answer to research question one is that there is no difference in satisfaction in environmental science between students participating in a traditional instruction mode and students participating in a flipped classroom instructional mode, for non-science major students at an open-enrollment college.

Limitations, implications, and results for research question two. In addition to the limitations described above for both research questions in this study, testing effects, specifically, survey fatigue, could have limited students' candid responses to the CUCEI survey. End-of-semester deadlines along with multiple college-wide survey-response requests and course examinations, may have affected students' responses. Students may not have spent quality time and effort completing the CUCEI survey, therefore the satisfaction with the classroom environment may not have been accurate. Further, the Likert-scale responses were valued 1-4 (Strongly disagree, disagree, agree, strongly agree) which may not have provided a wide range of response options. Most students responded with a 3 or 4 (agree or strongly agree). This small range of values narrowed satisfaction values to a mean value of approximately 3. Survey fatigue and the small range of response choices on the CUCEI may have impacted the data regarding students' level of satisfaction with the learning environment.

Statistical findings indicated no main effects of pretest scores or motivation on satisfaction with the learning environment. After controlling for pretest scores and motivation, the lecture class satisfaction scores were slightly higher, but not significantly higher (p = .697) than the flipped class satisfaction scores. The purpose of this study was to investigate the constructivist theory by comparing the flipped classroom and traditional learning environments. The findings in this investigation did not reject the null hypothesis associated with research question two. The significance of this finding implies that student satisfaction at an open-enrollment college does not differ significantly with respect to the learning environment.

Researchers reported mixed findings regarding students' satisfaction with the flipped classroom. Studies from a few years ago indicated that students were not satisfied with the flipped classroom (Mazur, 2009; Strayer, 2012; Zappe et al., 2009). However, more recent studies suggested that students are more satisfied with the flipped classroom learning environment (Hao, 2013; Lancaster, 2013; Long, Logan, & Waugh, 2013; Missilidine et al., 2013; Smith, 2013). This change in student satisfaction may be due to more available information about the best practices for flipping the class. In addition, the more experience an instructor gains implementing the flipped class learning environment, the more effective the learning environment (Bates & Galloway, 2012; Bergmann & Sams, 2012; Kettle, 2013; Lancaster, 2013). This dissertation adds to the findings on student satisfaction with the flipped classroom compared to the traditional lecture as well as findings involving students at an open-enrollment college

Recommendations

In practice, the findings from this study suggest that there is no difference in student achievement and student satisfaction in the flipped classroom compared to the traditional lecture classroom environment for students taking a science elective class at an open-enrollment college. The small mean differences in student achievement and satisfaction indicate that an increase in sample size may not result in significant findings even if the sample size is sufficient. As a result, no specific recommendation can be made regarding the implementation of the flipped classroom learning environment when considering student achievement and satisfaction. However, research on the flipped classroom should continue with students from a variety of academic backgrounds and in a variety of academic settings. Such studies will contribute to the literature about student learning in a flipped classroom learning environment.

Concerning research, several recommendations are made. First, replication of this study with an increase in sample size would result in more definitive results and limit the Type II errors. Future studies of the flipped classroom that investigate research questions similar to those in this study should include instructors with experience in flipped classroom implementation (Jaschik & Lederman, 2014). In addition, when comparing the traditional and flipped classroom learning environments, the instructor should provide instruction in both learning environments (control and treatment) to eliminate inconsistent instruction and potential limitations in the study.

To enhance the design of this study, a qualitative component could be added. A mixed-methods design would combine deductive and inductive inquiries and blend a variety of data to provide a more comprehensive view of the findings (Kalaian, 2008).

Satisfaction with the flipped classroom could be evaluated more accurately using a tool that collects qualitative findings that can be evaluated with quantitative findings (Hao, 2014; Kalaian, 2008; Missildine et al., 2013).

Motivation was determined using the AMS-C tool using the mean values from each category to give a self-determination index value for each student as it applied to reasons for being in college. Results from this survey may not have produced the true differences in motivation levels. Since this study occurred in a science course for non-science majors, a students' motivation to learn science may have more accurately measured the motivation level for the particular subject. A students' motivation to learn science can be measured using the Students' Motivation Towards Science Learning (SMTSL) survey (Tuan, Chin, & Shien, 2005). Using the SMTSL in place of the AMS-C may provide a wider range of motivation levels and influence achievement and satisfaction to a greater extent than the measures from the AMS-C tool.

Evaluative tools should be developed and validated for use in flipped classroom research. There are few empirical studies regarding the flipped classroom (Hao, 2014). With an increase in popularity, flipped classroom studies are essential (Kettle, 2013; Strayer, 2012). Individual differences influence students' outcomes to different learning environments (Hao, 2014; Kettle, 2013). Evaluative tools specific to the flipped classroom will help determine students' satisfaction and perspectives and add to the literature about the flipped classroom (Smith, 2013).

Since the flipped classroom is a student-centered learning environment, researchers should determine if specific metacognitive processes influence or are influenced by the flipped classroom learning environment. Subcategories of motivation to learn such as self-regulation and self-efficacy could be considered as variables in a flipped classroom learning environment. Researchers could consider these specific self-determination categories as variables that influence the achievement and satisfaction in the flipped classroom (Hao, 2014; Kettle, 2013). To this end, these differences should be taken into account when determining whether the flipped classroom learning environment is as effective as the traditional lecture (Hao, 2014; Kettle, 2013).

Since the flipped classroom is a relatively new approach to student-centered learning, the following research questions could be considered in future studies:

- What difference, if any, is there in student achievement between the lecture and flipped classroom learning environments when controlling for high school class rank for students at an open-enrollment college?
- What effects do self-regulation tools have on student satisfaction in the flipped classroom learning environment?
- To what degree does motivation toward learning science change in a flipped classroom compared to a lecture classroom?
- Is there a difference in long-term retention of content knowledge for students taught in a flipped classroom compared to students taught in a lecture classroom?
- What pre-class activities are most effective in preparing students for the face-to-face instructional time?
- How do students' motivation orientations affect the attitudes towards the flipped classroom learning environment?

Conclusions

In conclusion, no statistical difference in student achievement or satisfaction in the flipped classroom compared to the lecture learning environment when controlling for pre-knowledge and academic motivation was found from this study. Sample size was not sufficient to detect potential differences through ANCOVA analysis and should be increased in future studies. Studies involving the flipped classroom should be conducted with instructors who have experience with the implementation of the flipped classroom learning environment. A mixed-method design could be used to provide qualitative information about students' satisfaction while supporting this information with quantitative data.

Further studies involving the flipped classroom and student characteristics are recommended to provide future flipped classroom instructors with a more comprehensive view about the flipped classroom and student learning. Finally, this study provides evidence that the flipped classroom learning environment does not negatively or positively affect student achievement or satisfaction. These findings are valuable to those instructors who are concerned about the negative impact on student achievement and satisfaction upon implementation of the flipped classroom approach. However, in light of these findings, no specific recommendation can be made regarding the implementation of the flipped classroom learning environment when considering student achievement and satisfaction for non-science major students at an open-enrollment college.

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Appendixes

Appendix A: AMS-C survey

ACADEMIC MOTIVATION SCALE (AMS-C 28)

COLLEGE (CEGEP) VERSION

Robert J. Vallerand, Luc G. Pelletier, Marc R. Blais, Nathalie M. Brière, Caroline B. Senécal, Évelyne F. Vallières, 1992-1993

Educational and Psychological Measurement, vols. 52 and 53

Scale Description

This scale assesses the same 7 constructs as the Motivation scale toward College (CEGEP) studies. It contains 28 items assessed on a 7-point scale.

References

Vallerand, R.J., Blais, M.R., Brière, N.M., & Pelletier, L.G. (1989). Construction et validation de l'Échelle de Motivation en Éducation (EME). Revue canadienne des sciences du comportement, 21, 323-349.

WHY DO YOU GO TO COLLEGE (CEGEP) ?

Using the scale below, indicate to what extent each of the following items presently corresponds to one of the reasons why you go to college.

Does not correspond at all	Corresponds a little	Corresponds moderately	Corresponds a lot	Corresponds exactly
1	2	3	4	5

WHY DO YOU GO TO COLLEGE (CEGEP) ?

1. Because with only a high-school degree I would not find a high-paying job later on.
1 2 3 4 5

2. Because I experience pleasure and satisfaction while learning new things.
1 2 3 4 5

3. Because I think that a college education will help me better prepare for the career I have chosen.
1 2 3 4 5

4. For the intense feelings I experience when I am communicating my own ideas to others.
1 2 3 4 5

5. Honestly, I don't know; I really feel that I am wasting my time in school.
1 2 3 4 5

6. For the pleasure I experience while surpassing myself in my studies.
1 2 3 4 5

7. To prove to myself that I am capable of completing my college degree.
1 2 3 4 5

8. In order to obtain a more prestigious job later on.
1 2 3 4 5

9. For the pleasure I experience when I discover new things never seen before.
1 2 3 4 5

10. Because eventually it will enable me to enter the job market in a field that I like.
1 2 3 4 5

11. For the pleasure that I experience when I read interesting authors.

1 2 3 4 5

12. I once had good reasons for going to college; however, now I wonder whether I should continue.
1 2 3 4 5

13. For the pleasure that I experience while I am surpassing myself in one of my personal accomplishments.
1 2 3 4 5

14. Because of the fact that when I succeed in college I feel important.
1 2 3 4 5

15. Because I want to have "the good life" later on.
1 2 3 4 5

16. For the pleasure that I experience in broadening my knowledge about subjects which appeal to me.
1 2 3 4 5

17. Because this will help me make a better choice regarding my career orientation.
1 2 3 4 5

18. For the pleasure that I experience when I feel completely absorbed by what certain authors have written.
1 2 3 4 5

19. I can't see why I go to college and frankly, I couldn't care less.
1 2 3 4 5

20. For the satisfaction I feel when I am in the process of accomplishing difficult academic activities.
1 2 3 4 5

21. To show myself that I am an intelligent person.
1 2 3 4 5

22. In order to have a better salary later on.
1 2 3 4 5

23. Because my studies allow me to continue to learn about many things that interest me.

1 2 3 4 5

24. Because I believe that a few additional years of education will improve my competence as a worker.

1 2 3 4 5

25. For the "high" feeling that I experience while reading about various interesting subjects.
1 2 3 4 5

26. I don't know; I can't understand what I am doing in school.
1 2 3 4 5

27. Because college allows me to experience a personal satisfaction in my quest for excellence
in my studies.
1 2 3 4 5

28. Because I want to show myself that I can succeed in my studies.
1 2 3 4 5

KEY FOR AMS-28

2, 9, 16, 23 Intrinsic motivation - to know

6, 13, 20, 27 Intrinsic motivation - toward accomplishment

4, 11, 18, 25 Intrinsic motivation - to experience stimulation

3, 10, 17, 24 Extrinsic motivation - identified

7, 14, 21, 28 Extrinsic motivation - introjected

1, 8, 15, 22 Extrinsic motivation - external regulation

5, 12, 19, 26 Amotivation

Appendix B: Pretest/Posttest Questions

Multiple Choice: Using the Op-Scan sheet to record your answers, select the BEST choice to answer each question for 1-27.

1. The scientific method is the process that scientists use to:
A) evaluate science students' learning.
B) rigorously test potential solutions to questions they propose about phenomena they observe.
C) generate hypotheses about phenomena that are invisible to the naked eye.
D) all of the above

2. The fundamental steps followed in the scientific method include:
A) make an observation, think about it, offer explanations of what is occurring for other scientists to examine and debate.
B) observation, formulate and test a hypotheses, compare results to others and publish findings so other scientists can evaluate your work.
C) make an observation, interview other scientists about their research, and synthesize the answer from their findings and data.
D) all of the above.

3. A hypothesis is
A) an instrument that is used to examine environmental conditions.
B) a consensus about something whose causes are currently uncertain.
C) a proven scientific fact.
D) an educated guess that explains a phenomenon or answers a question.
E) the design of an experiment that can be used for the process of science.

4. An experiment
A) does not need to be repeated.
B) involves only collection of quantitative data.
C) is designed to prove a scientific hypothesis.
D) often involves manipulating as many variables as possible.
E) is an activity designed to test the validity of a hypothesis

5. The pH scale was devised to quantify the _______ of a solution.
A) plasticity
B) hardness
C) toxicity
D) acidity
E) salinity

6. Cellular respiration
A) represents a decrease in entropy.
B) consumes sugars and oxygens in an oxidation reaction that releases energy organisms can use and carbon dioxide as a waste product.

C) could be characterized as a sort of endothermic reaction.
D) creates high energy molecules from low energy ones.
E) requires the green pigment chlorophyll.

7. During photosynthesis,
A) oxygen is consumed.
B) entropy increases more rapidly.
C) plants absorb CO_2 and use sunlight to drive a chemical reaction where water is chemically broken down to bind hydrogens (from water) to carbons (from CO_2) to make high energy sugar molecules. Oxygen is released as a waste product.
D) the high-quality energy of the sun is converted to a lower quality.
E) entropy stays the same.

8. The carrying capacity is the
A) maximum population size of a species that a given environment can sustain.
B) potential number of species in a given area.
C) average number of viable offspring produced within a population.
D) maximum reproductive potential of an individual of a particular species.
E) greatest number of niches possible in a given area.

9. Extinction is
A) proceeding more slowly in 2009 than at any time in the past.
B) caused exclusively by human disturbance.
C) the loss of communities from ecosystems.
D) a natural AND human influenced process that results in the permanent elimination of a species from the planet.
E) most likely to affect wide-ranging generalist species.

10. Communities
A) are temporary associations of a variety of populations of different species living in the same
place at the same time.
B) have definite spatial limits, and limits to the number of species living there.
C) are fixed groups of specific organisms that live in the same place over many thousands of years.
D) are associations of individuals of a single species living in the same place at the same time.

11. Mercury is not readily excreted; it is stored in mammalian body tissues. This is best described as
A) biomagnification.
B) toxification.
C) synergism .
D) bioaccumulation.

12. The bald eagle, brown pelican, and peregrine falcon all are top predators that have

been found to be uniquely susceptible to
A) over-hunting for their feathers.
B) the swine flu.
C) U.S. invasive species.
D) eggshell damage caused by DDT.

13. Synergistic effects of toxicants .
A) always involve synthetic toxicants
B) have effects that tend to cancel one another out.
C) typically have simple additive effects.
D) are not numerous in the natural environment.
E) often have effects that are multiplicative.

14. Precipitation that falls on Earth's surface
A) almost entirely filters down into the underground aquifers.
B) is mostly taken up by plants or other organisms.
C) is usually already unusable because of acid rain.
D) may take a variety of pathways in the hydrologic cycle.

15. In a municipal water treatment plant, the treatments
A) reduce or remove nutrients.
B) remove large debris and allowing suspended solids to settle.
C) remove bacteria, viruses, and other pathogens.
D) filter the sewage for all debris and grit.
E) all of the above

16. The fish in the lake at the local park are dying. A professor from the local college comes to investigate, and first she measures the dissolved oxygen. She wants to check the .
A) aquatic biodiversity.
B) if oxygen levels are low due to aerobic bacteria consuming an excess of photosynthetic biomass generated by high nutrient inputs (fertilizer, etc).
C) presence of heavy metals.
D) presence of viruses.

17. Only about 2.5% of all the water on our planet is freshwater. Most of it is found in
A) underground aquifers.
B) polar ice caps.
C) large, freshwater lakes and rivers.
D) undersea caverns.

18. What is the combustion of fossil fuels by humans doing to the Earth's climate?
A) Adding measurable quantities of CO_2 to the atmosphere. This increases the Earth's atmosphere's ability to retain solar heat, and has slowly but measurably caused Earth's overall climate to warm in the past two centuries and has unknown long-term future consequences.

B) Adding Ozone to Earth's upper ozone layer, causing Earth's climate to heat up.
C) It is doing nothing measurable to Earth's climate, the changes are more complicated than humans can ever understand and the concern is nothing more than a bunch of scientists with radical views.
D) It causes acid rain, but nothing else more significant.

19. For the United States, the primary energy source fueling our transportation system is
A) nuclear.
B) coal.
C) wood.
D) oil.
E) natural gas.

20. Atomic energy in power plants is created via
A) the capture of heat released from the fission of uranium atoms splitting due to the addition or
subtraction of neutrons.
B) bombarding cathode ray tubes with electrons.
C) ionic transformation of atoms.
D) fusion of electrons.
E) extraction of energy from the nucleus of cells and cellulose.

21. The largest category, worldwide, of renewable resources currently used is .
A) coal.
B) biomass.
C) hydroelectric.
D) solar.
E) wind.

22. Today, the human population totals about ________.
A) the same as for the past six years, 5.35 billion.
B) 9 billion.
C) 10 billion.
D) 7 billion.
E) 2% less than it did in 2010.

23. Which terrestrial biome has the most biodiversity?
A) temperate deciduous forest
B) prairie
C) tropical rainforest
D) temperate rainforest
E) boreal forest

24. Factors involved in soil formation include:
A) nitrogen-fixing bacteria, grazing by herbivores, tropical storms

B) erosion, leaching
C) weathering of parent material, freezing/thawing, tree roots
D) frequent wildfires, wind, temperatures above 100 ^{o}F.
E) seasonal changes in tides, earthquakes

25. To safeguard against groundwater contamination, sanitary landfills are
A) located on slopes so water runs downhill.
B) lined with plastic and clay.
C) lined with cement.
D) located in unpopulated areas.
E) located on industrial sites where groundwater is not used for drinking or agriculture.

26. Molecules that contain carbon and hydrogen atoms joined by covalent bonds with or without other elements are considered
A) salts.
B) inorganic.
C) organic.
D) phosphates.
E) a by-product of abiotic processes.

27. The correct sequence of events in a chemical reaction is
A) exothermic → reaction→ products
B) reactants → reaction→ products
C) reaction → exothermic→ reactants
D) reactants → products→ reaction

Appendix C: CUCEI survey

College and university classroom environment inventory (CUCEI) Actual form

Directions

The purpose of this questionnaire is to find out your opinions about the class you are attending right now. This questionnaire is designed for use in gathering opinions about small classes at universities or colleges (sometimes referred to as seminars or tutorials). It is not suitable for the rating of lectures or laboratory classes.

This form of the questionnaire assesses your opinion about what this class is actually like.

Indicate your opinion about each questionnaire statement by choosing:

SA if you STRONGLY AGREE that it describes what this class is actually like.
A if you AGREE that it describes what this class is actually like.
D if you DISAGREE that it describes what this class is actually like.
SD if you STRONGLY DISAGREE that it describes what this class is actually like.

All responses should be given selected electronically in the Qualtrics survey software.

1. The instructor considers students' feelings.

2. The instructor talks rather than listens.

3. The class is made up of individuals who don't know each other well.

4. The students look forward to coming to classes.

5. Students know exactly what has to be done in our class.

6. New ideas are seldom tried out in this class.

7. All students in the class are expected to do the same work, in the same way and in the same time.

8. The instructor talks individually with students.

9. Students put effort into what they do in classes.

10. Each student knows the other members of the class by their first names.

11. Students are dissatisfied with what is done in the class.

12. Getting a certain amount of work done is important in this class.

13. New and different ways of teaching are seldom used in this class.

14. Students are generally allowed to work at their own pace.

15. The instructor goes out of his/her way to help students.

16. Students "clockwatch" in this class.

17. Friendships are made among students in this class.

18. After the class, the students have a sense of satisfaction.

19. The group often gets sidetracked instead of sticking to the point.

20. The instructor thinks up innovative activities for students to do.

21. Students have a say in how class time is spent.

22. The instructor helps each student who is having trouble with the work.

23. Students in this class pay attention to what others are saying.

24. Students don't have much chance to get to know each other in this class.

25. Classes are a waste of time.

26. This is a disorganized class.

27. Teaching approaches in this class are characterized by innovation and variety.

28. Students are allowed to choose activities and how they will work.

29. The instructor seldom moves around the classroom to talk with students.

30. Students seldom present their work to the class.

31. It takes a long time to get to know everybody by his/her first name in this class.

32. Classes are boring.

33. Class assignments are clear so everyone knows what to do.

34. The seating in this class is arranged in the same way each week.

35. Teaching approaches allow students to proceed at their own pace.

36. The instructor isn't interested in students' problems.

37. There are opportunities for students to express opinions in this class.

38. Students in this class get to know each other well.

39. Students enjoy going to this class

40. This class seldom starts on time.

41. The instructor often thinks of unusual class activities.

42. There is little opportunity for a student to pursue his/her particular interest in this class.

43. The instructor is unfriendly and inconsiderate towards students.

44. The instructor dominates class discussions.

45. Students in this class aren't very interested in getting to know other students.

46. Classes are interesting.

47. Activities in this class are clearly and carefully planned.

48. Students seem to do the same type of activities every class.

49. It is the instructor who decides what will be done in our class.

Appendix D: Flipped Classroom Welcome Email

Welcome to Introduction to Environmental Science!

My name is Rob Cooley and I will be the instructor for this course.

Visit your course website prior to the first day of class. Here you will find the syllabus and calendar along with the course content. The website for the course can be accessed by pointing your browser to: https://learn.pct.edu/d2l/le/content/8023/Home

SCI 100 -01 will be meeting for class in room ________. Our first class meeting will be on ______. If you have a laptop or tablet, bring it to class!!

You will be taught environmental science this semester using a student-centered approach. The pedagogical practice is called the "flipped" classroom.
Here is a good overview click on the Wikipedia link below.
Wikipedia on Flip
AT HOME, you will:

- read and take notes on the text
- watch the vodcast lecture found in PLATO
- Write down any questions you might have.
- come to class prepared to work on lots of problems.

IN CLASS, you will:

- Spend the first few minutes reviewing.
- Tell me what you want to learn that day.
- You will work in groups of 3-4 students on an activity.
- One student will record the answers and submit the answers as a group.

IN CLASS, I will:

- Answer your questions from the textbook readings and/or vodcast.
- Roam the room and answer your questions.
- Pause the class to clear up any misconceptions.

What if I need accommodations?

Disability Services and Student Requests for Accommodations:
Any student who feels she/he may need an accommodation based on the impact of a disability should contact me privately to discuss your specific needs. However, determination of your eligibility for accommodations will be based upon the documentation that you must submit to the Disability Services' Office. Please contact the Disability Services Office at 570-326-3761 ext. 7803, Klump Academic Center Room 148, to discuss the necessary steps toward coordinating reasonable accommodations for students with documented disabilities.

Prior to our first class:

Purchase the textbook:

Post an Introduction of yourself to the **Introductions** discussion board (DB). This can be accessed by going to Lessons →Content →Getting Started Module. This introduction should include:

- Name
- Hometown
- Major
- Science course background
- Aspect of this course that concerns you most
- Fun fact about yourself

Read the syllabus!!

Post at least one question you have regarding the syllabus or course on the discussion board labeled **Syllabus/course questions** in the Getting Started Module (right under the Introductions!). It is your responsibility to read the syllabus prior to the first class. I will not be reviewing the entire syllabus on this day.

Get started now!! You can begin by reading and taking notes on Ch. 1 as well as watching the first vodcast found in the Course site. Go to Lessons → Content → Part 1 Introduction → Chapter 1 → Assignments Chapter 1. The vodcast can be accessed by clicking on the blue hyperlink Chapter 1 Vodcast. We will also be viewing this in class.

I'm looking forward to meeting and interacting with all of you. Environmental Science is a lot of fun, but challenging. With careful attention to detail and asking lots of questions, you can be successful.

Sincerely,

Rob Cooley, Assistant Professor

Appendix E: Informed Consent Flipped Group

Informed Consent Form

The Effects of Motivation on Achievement and Satisfaction in a Flipped Classroom Learning Environment

Purpose. You are invited to participate in research being conducted for a doctoral study at Pennsylvania College of Technology, Williamsport, Pennsylvania. The purpose of this study is to examine student success and satisfaction with a science elective course taught using the flipped classroom pedagogical approach. There is no deception in this study. We are interested in your opinions about the experiences in this learning environment.

Participation requirements. If you are enrolled in SCI 100-01 you will be taught in a flipped classroom learning environment. A description of the flipped classroom methodology was sent to students in SCI 100-01 via the Penn College email system. Please view this description before agreeing to participation in the study.

Research Personnel. The following people are involved in this research project and may be contacted at any time: Kelly B. Butzler (researcher) and D. Robert Cooley (course instructor).

Potential Risk/ Discomfort. Although there are no known risks in this study, you may choose to **not** participate in the study at any point during the semester.

- If you do not want to take part in the flipped learning environment, please select and initial the first choice listed below: ***"I do not want to take an environmental science course taught using the flipped classroom learning environment"***. You will be assisted in finding an appropriate alternate science course or section of SCI 100. Environmental Science is generally offered every semester so you may choose to wait to take this course next semester or select another section this semester if the flipped classroom learning environment is not a desirable environment for your learning style. Please send an email to Kelly Butzler (kbutzler@pct.edu) to discuss alternatives.

- If you choose to take part in the learning environment AND participate in the study, select and initial the second choice listed below: ***"I do want to take an environmental science taught using the flipped classroom learning environment and I choose to participate in this study".***

If you choose to participate in this study, you will be asked to complete a pretest, Academic Motivation Survey, and a College and University Classroom Environment Inventory.

- If you choose to take part in the learning environment but not the research please select and initial the third choice listed below: ***"I do want to take an environmental science taught using the flipped classroom learning environment, but I choose***

not to participate in this study".

Potential Benefit. There are no direct benefits to you of participating in this research. No incentives are offered. The results will have educational interest that may eventually have benefits for instructors who want to teach using the flipped classroom methodology.

Anonymity/ Confidentiality. The data collected in this study are confidential. All data will be coded such that your name is not associated with them. In addition, the coded data are made available only to the researchers associated with this project.

Right to Withdraw. You have the right to withdraw from SCI 100 prior to the withdrawal date listed in the syllabus.

I would be happy to answer any questions that may arise about the study. Please direct your questions or comments to: kbutzler@pct.edu

I have read the above description of the study and understand the conditions of my participation. Please select the appropriate radio button below and add your initials to the text box.

Signatures

I have read the above description of the study and understand the conditions of my participation. The checked box indicates that I agree to participate in this study.

***I do not want to take an environmental science course taught using the flipped classroom learning environment*.**

I do want to take an environmental science taught using the flipped classroom learning environment and I choose to participate in this study.

I do want to take an environmental science taught using the flipped classroom learning environment, but I choose not to participate in this study.

Appendix F: Traditional Class Welcome Email

Welcome to Introduction to Environmental Science!

My name is Veronica Ciavarella and I will be the instructor for this course.

Visit your course website prior to the first day of class. Here you will find the syllabus and calendar along with the course content. The website for the course can be accessed by pointing your browser to: https://learn.pct.edu/d2l/le/content/8023/Home

SCI 100 -01 will be meeting for class in room ________. Our first class meeting will be on ______. If you have a laptop or tablet, bring it to class!!

You will be taught environmental science this semester using a traditional approach.
AT HOME, you will:

- read and take notes assigned text or websites.
- complete an activity corresponding to the lecture content reviewed in class.

IN CLASS, you will:

- listen and take notes on a lecture delivered by the instructor.

IN CLASS, I will:

- Answer your questions from the lecture.

What if I need accommodations?
Disability Services and Student Requests for Accommodations:
Any student who feels she/he may need an accommodation based on the impact of a disability should contact me privately to discuss your specific needs. However, determination of your eligibility for accommodations will be based upon the documentation that you must submit to the Disability Services' Office. Please contact the Disability Services Office at 570-326-3761 ext. 7803, Klump Academic Center Room 148, to discuss the necessary steps toward coordinating reasonable accommodations for students with documented disabilities.

Prior to our first class:

Purchase the textbook:

Post an Introduction of yourself to the **Introductions** discussion board (DB). This can be accessed by going to Lessons →Content →Getting Started Module. This introduction should include:

- Name
- Hometown

- Major
- Science course background
- Aspect of this course that concerns you most
- Fun fact about yourself

Read the syllabus!!

Post at least one question you have regarding the syllabus or course on the discussion board labeled **Syllabus/course questions** in the Getting Started Module (right under the Introductions!). It is your responsibility to read the syllabus prior to the first class. I will not be reviewing the entire syllabus on this day.

Get started now!! You can begin by reading and taking notes on Ch. 1

I'm looking forward to meeting and interacting with all of you. Environmental Science is a lot of fun, but challenging. With careful attention to detail and asking lots of questions, you can be successful.

Sincerely,

Veronica (Roni) Ciavarella, Assistant Professor

Appendix G: Informed Consent Traditional Group

Informed Consent Form

The Effects of Motivation on Achievement and Satisfaction in a Flipped Classroom Learning Environment

Purpose. You are invited to participate in research being conducted for a doctoral study at Pennsylvania College of Technology, Williamsport, Pennsylvania. The purpose of this study is to examine student success and satisfaction with a science elective course taught using the flipped classroom pedagogical approach. There is no deception in this study. We are interested in your opinions about the experiences in this learning environment.

Participation requirements. If you are enrolled in SCI100-02 you will be taught in a traditional lecture learning environment. A description of the traditional lecture methodology was sent to students in SCI100-02 via the Penn College email system. Please view this description before agreeing to participation in the study.

- If you do not want to take part in the study, please select and initial the first choice listed below: ***"I choose to not participate in the study"***. You will be assisted in finding an appropriate alternate science course.

  SCI 100 is generally offered every semester so you may choose to wait to take this course next semester or select another section this semester if you do not wish to participate in the study. Please send an email to Kelly Butzler (kbutzler@pct.edu) to discuss alternatives.

- If you choose to participate in the study, select and initial the second choice listed below: ***"I choose to participate in this study"***.

  If you choose to participate in this study, you will be asked to complete a pretest, Academic Motivation Survey, and a College and University Classroom Environment Inventory.

Research Personnel. The following people are involved in this research project and may be contacted at any time: Kelly B. Butzler (researcher) and Veronica Ciavarella (course instructor).

Potential Risk/ Discomfort. Although there are no known risks in this study, you may choose another science elective course before week two of the semester if you do not feel comfortable participating in the study. SCI 100 is generally offered every semester so you may choose to wait to take this course next semester. Please send an email to Kelly Butzler (kbutzler@pct.edu) to discuss alternate courses.

Potential Benefit. There are no direct benefits to you of participating in this research. No incentives are offered. The results will have educational interest that may eventually have benefits for instructors who want to teach using the flipped classroom methodology.

Anonymity/ Confidentiality. The data collected in this study are confidential. All data will be coded such that your name is not associated with them. In addition, the coded data are made available only to the researchers associated with this project.

Right to Withdraw. You have the right to withdraw from SCI 100 prior to week two of the semester with no financial penalties. Further, you may choose not to participate in the study at any point in the semester.

I would be happy to answer any questions that may arise about the study. Please direct your questions or comments to: kbutzler@pct.edu

Signatures

I have read the above description of the study and understand the conditions of my participation. The checked box indicates that I agree to participate in this study.

I choose to not participate in the study.

I choose to participate in this study.

.

Appendix H: Approval Letter from Target Institution

Pennsylvania College of Technology

PENNSTATE

One College Avenue
Williamsport, PA 17701-5799

(570) 326-3761
www.pct.edu

August 22, 2013

Ms. Kelly B. Butzler
200 Creek View Lane
Jersey Shore, PA 17740-8569

Dear Ms. Butzler,

Please accept this letter as notification that you have been granted permission to conduct research on "the Effects of Motivation on Achievement and Satisfaction in a Flipped Classroom Learning Environment". Your application and all associated materials have been reviewed and they meet expectations for human subject research at the Pennsylvania College of Technology.

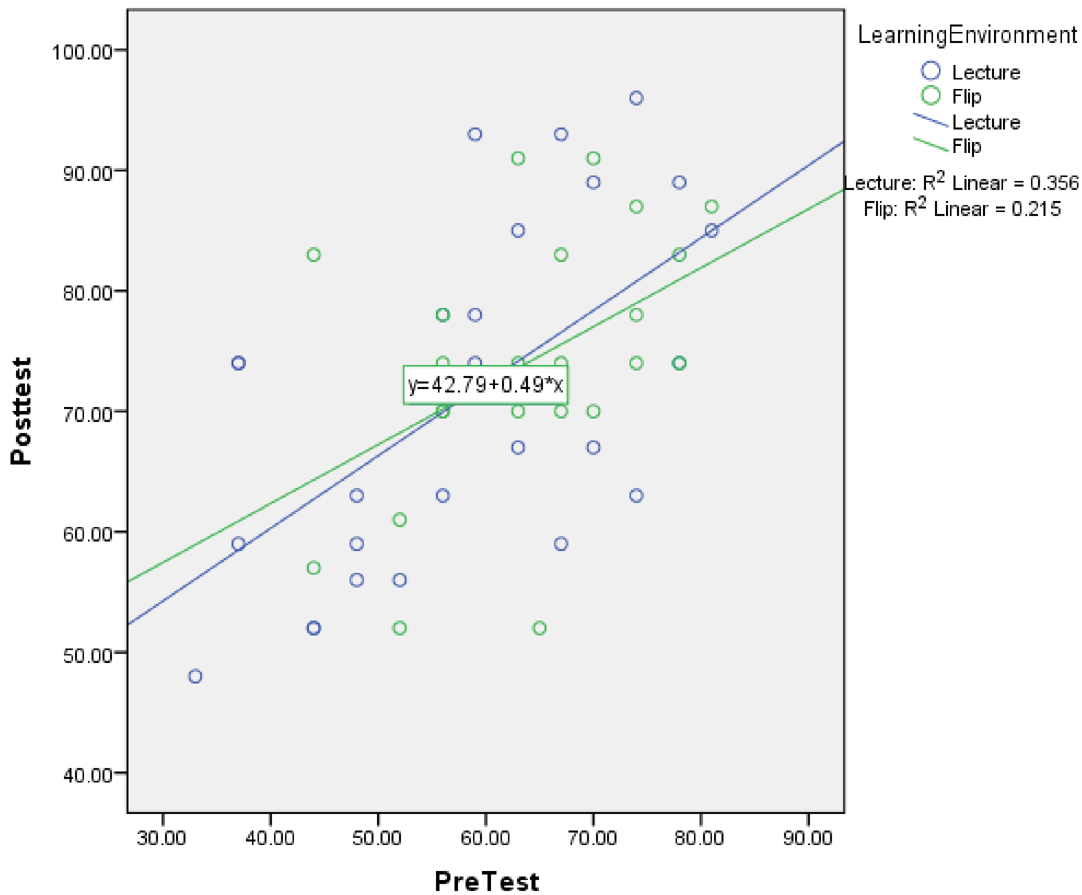
Should you need any further assistance from me do not hesitate to contact my office. I wish you the best of luck on a successful research project and dissertation.

Best regards,

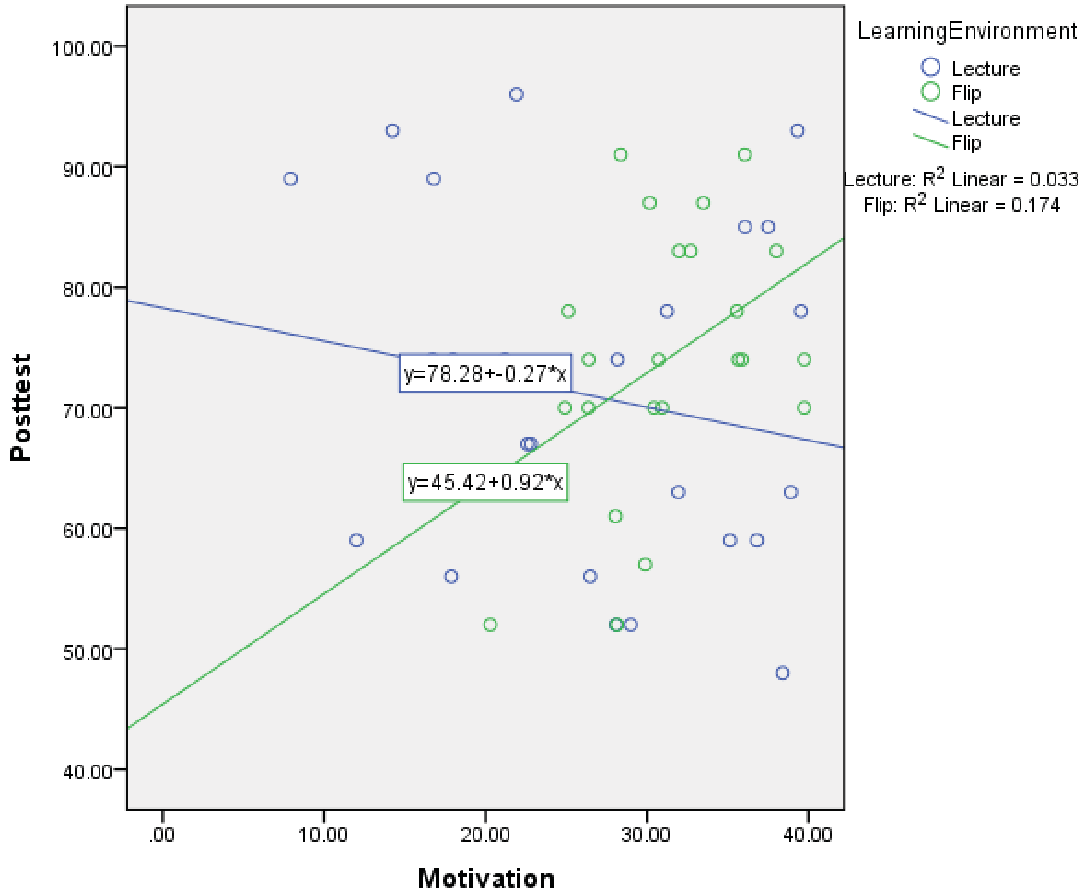
Paul Starkey
Vice President for Academic Affairs/Provost

Appendix I: Scatterplots for Regression Assumptions

Plot 1

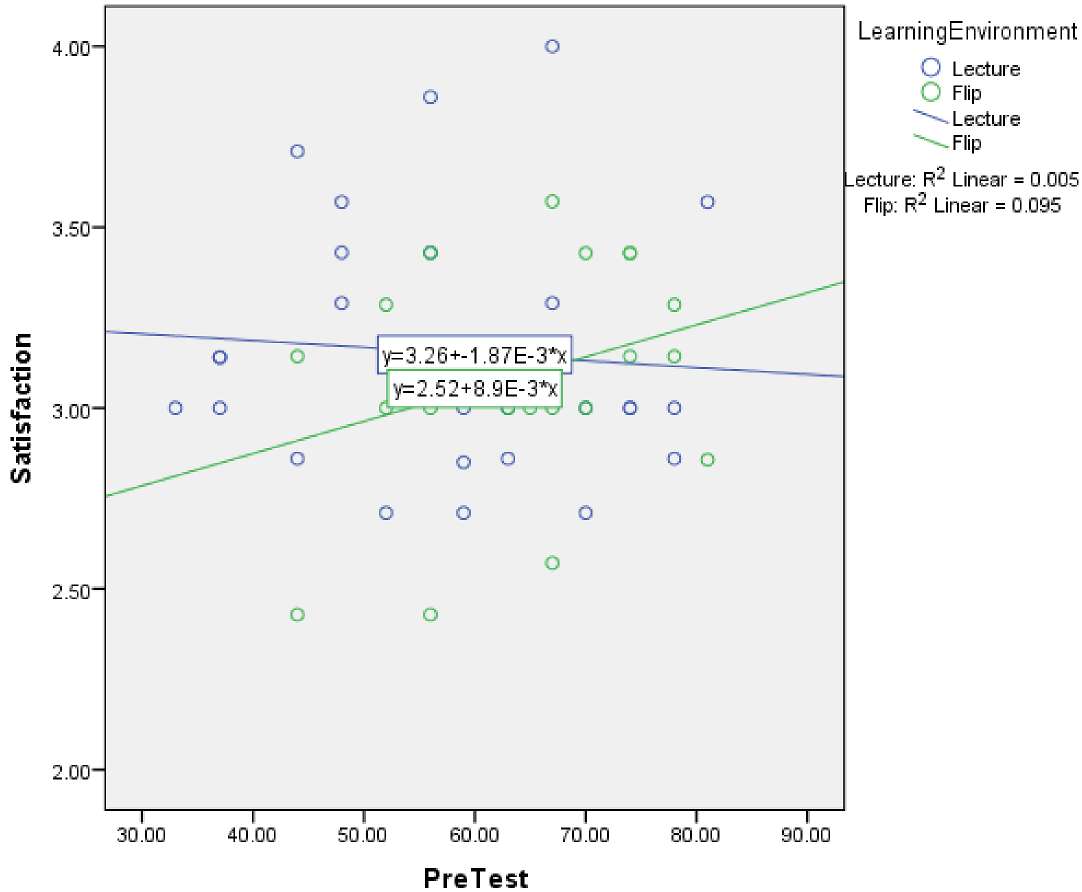


Plot 2

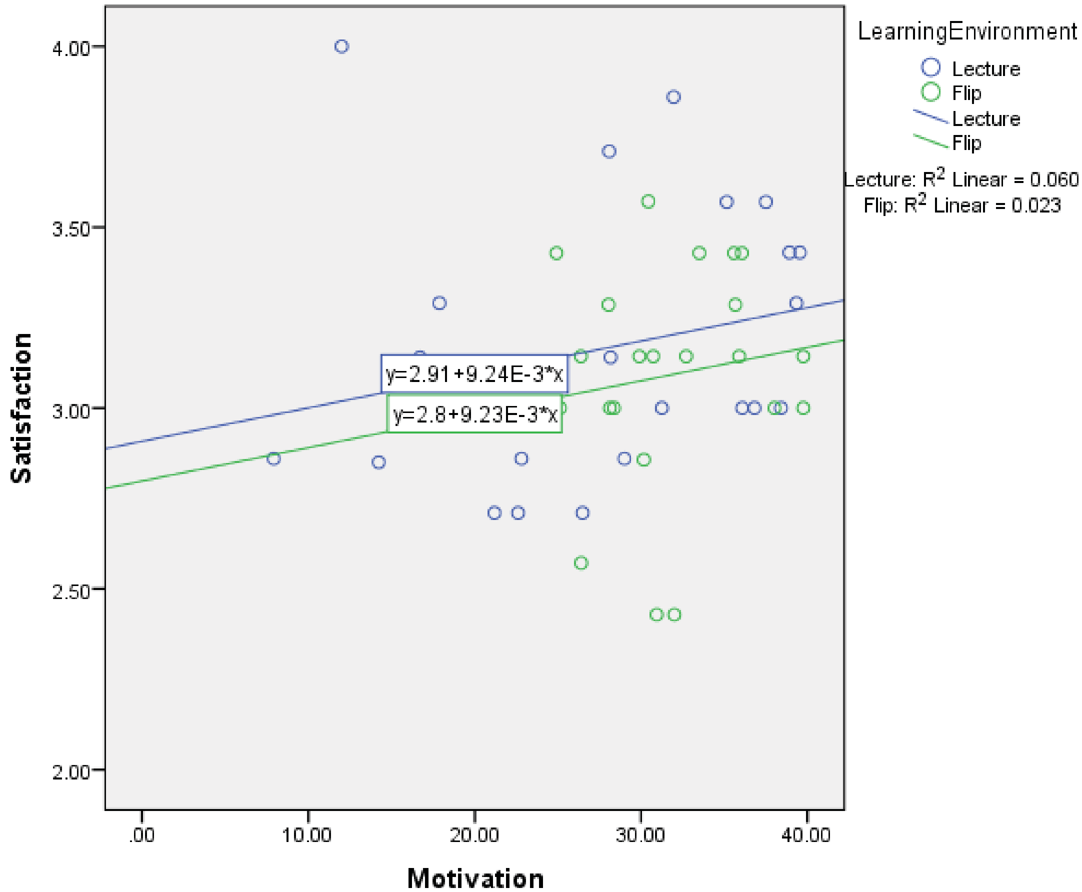


LearningEnvironment
Lecture
Flip
Lecture
Flip
Lecture: R2 Linear = 0.033
Flip: R2 Linear = 0.174
y=78.28+-0.27*x
y=45.42+0.92*x
100.00
90.00
80.00
70.00
60.00
50.00
40.00
Posttest
.00
10.00
20.00
30.00
40.00
Motivation

Plot 3


LearningEnvironment
Lecture
Flip
Lecture
Flip
Lecture: R2 Linear = 0.005
Flip: R2 Linear = 0.095
y=3.26+-1.87E-3*x
y=2.52+8.9E-3*x
Satisfaction
PreTest
4.00
3.50
3.00
2.50
2.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00

Plot 4



LearningEnvironment
Lecture
Flip
Lecture
Flip
Lecture: R^2 Linear = 0.060
Flip: R^2 Linear = 0.023
y=2.91+9.24E-3*x
y=2.8+9.23E-3*x
Satisfaction
4.00
3.50
3.00
2.50
2.00
.00
10.00
20.00
30.00
40.00
Motivation