ABSTRACT

KELLY, DANIEL PATRICK. STEM Teacher Efficacy in Inverted Classrooms. (Under the direction of Dr. Cameron D. Denson).

The purpose of this research was to determine the impact inverted classrooms and curricula have on teacher efficacy. This study uses a transcendental phenomenological approach to analyze interviews conducted with three science, technology, engineering, and mathematics (STEM) teachers working in inverted classrooms in a public charter high school. The analysis focused on how the studied teachers' perceptions and experience of the inverted classroom model impacted their teacher efficacy based on four factors: experience, vicarious experience, and social persuasion, and physiological factors. This research adds to the literature, a framework from which to more deeply analyze those themes that contribute to the successes of the teachers studied. Also important is gaining insight into factors that may contribute to teachers' inefficacious application of the inverted classroom model. Driven by two fundamental questions: (a) What are STEM teachers' perceptions of inverted classrooms? and (b) How do STEM teachers' perceptions and/or use of inverted classrooms affect their teacher efficacy to teach in an inverted classroom environment? Participants in this study perceived the use of the method to be largely positive including increased time during class to cover material and address student misconceptions in real time. This study also identifies the need for further study into the phenomenon of inverted classrooms within the K-12 domain.

INDEX WORDS: Inverted classrooms, flipped classrooms, teacher efficacy, STEM education, perceptions, teaching methods

STEM Teacher Efficacy in Inverted Classrooms

by
Daniel Patrick Kelly

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APPROVED BY:

_____	_____
Dr. Aaron C. Clark	Dr. Matthew D. Lammi

_____
Dr. Cameron D. Denson
Committee Chair

DEDICATION

This work is dedicated to all my students. You have been my inspiration and motivation throughout this process. I sincerely hope to be a positive force in education to help create an environment from which all students are encouraged to become lifelong learners.

BIOGRAPHY

Daniel Patrick Kelly was born on April 21, 1980 in North Tonawanda, New York. He enlisted in the United States Navy upon graduation from Niagara-Wheatfield High School in Sanborn, New York. Daniel completed his Bachelor of Arts degree in Physics at the State University of New York College at Potsdam where he also studied Secondary Science Education as a graduate student.

Daniel started his Master of Science Degree program at North Carolina State University after teaching middle school technology and engineering courses in Durham, North Carolina. He plans to pursue a Doctor of Education degree in Technology Education. His research and academic interests include flipped classrooms, technology integration, and technological literacy standards for current and pre-service educators.

Daniel Kelly has served his community as a volunteer firefighter, EMT, and currently uses the proceeds of his book *Falling Down* to support a non-profit organization he founded to help at-risk youth and families.

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CHAPTER 1: INTRODUCTION

Since the evolution and subsequent large-scale use and adoption of the Internet, educators have looked for methods to integrate Internet-based resources into their curricula. One incarnation of this phenomenon has been the inverted classroom. Colloquially called the "flipped" classroom, inverted classrooms take information and instruction typically given face-to-face in the classroom and deliver it outside that environment (Lage, Platt, & Treglia, 2000). Much of the current movement towards inverting the classroom can be traced back to Alison King's (1993) paper that advocated a change from the teacher as the "sage on the stage" to being the "guide on the side." In this model, the teacher facilitates instruction rather than delivering content in a more direct, whole group manner.

Digital, Internet-based, multimedia technologies have allowed educators the ability to efficiently distribute pre-recorded lectures and presentations to the students rather than dubbing video cassette tapes or providing video lab access to students outside of class time as documented in early studies and examples of inverted courses (Lage et al., 2000). Further Internet-based technologies such as Khan Academy, Discovery Education, and YouTube provide resources to teachers and schools wishing to invert learning and supplement teacher-made presentations for students to view asynchronously outside of class. This frequent use of these programs illustrates the importance of research into their impact on teacher efficacy.

The purpose of this study is to examine the effect inverted classrooms have on teacher efficacy for those educators teaching Science, Technology, Engineering, and Mathematics (STEM) subjects. Teacher efficacy, born out of Paul Berman's 1977 study, is defined as "the

extent to which the teacher believe[s] he or she [has] the capacity to affect student performance" (p.137). Teachers who have embraced – whether by choice or policy – the inverted classroom model, spend a greater amount of time and resources preparing each lesson due to the need to pre-record and distribute the lecture component of the course while still needing to prepare the materials for the in-class element (Bergmann & Sams, 2014). The addition of video lectures for asynchronous viewing essentially adds time to the course exceeding the instructional time that teachers and students in traditional classroom settings might have. This greater instructional time means more content must be planned for and potentially adds greater workloads to those teachers engaged in inverted classroom environments.

STEM content, with a more natural tendency toward inquiry and problem-based learning (Roberts, 2012), may provide a more efficient platform for inverted classrooms. Students receiving lecture and foundational information outside the classroom grants more time available for hands-on and collaborative work inside the classroom. This also leaves the teacher free to facilitate instruction and focus on higher-order learning objectives.

Inverted classrooms have risen out of two often contradicting theoretical frameworks: behaviorism and constructivism (Bishop & Verleger, 2013). Behaviorism (teacher-led), which equates learning with changes in observable performance, is evident in generally non-interactive video-based lessons from which teachers disseminate foundational information to the students (Bishop & Verleger, 2013; Ertmer & Newby, 2013). Student-centric classroom activities based in constructivism, knowledge constructed in the mind of the learner, provide

a platform for students to use prior and collaborative knowledge gained from their peers during group work (Bishop & Verleger, 2013; Bodner, 1986; Harris & Alexander, 1998). The coalescence of two apparently dichotomous frameworks into one method of academic content delivery warrants study into its effect on teacher efficacy.

Teacher efficacy, while similar to Albert Bandura's (1977) construct of self-efficacy, diverges when discussing outcome expectancy. Self-efficacy describes outcome expectancy as the anticipated outcome for oneself (Bandura, 1997) while teacher efficacy is predicated on the outcomes expected for others (Tschannen-Moran, Hoy, & Hoy, 1998), in this case, the students' performance, not the teachers'. Like Bandura's self-efficacy, teacher efficacy levels are impacted by mastery experience, vicarious experience, and social persuasion (Bandura, 1977; Protheroe, 2008). Teacher efficacy is highly context dependent and subject specific (Tschannen-Moran & Hoy, 2001). Teachers may experience high levels of efficacy in a particular subject or with one group of students, but low efficacy levels with different groups or subject matter.

Justification

This research seeks to investigate teacher efficacy levels in classrooms where there is a focus on inverted instructional methods when teaching STEM content. STEM curricula has become a focus in many schools since the acronym's first use by the National Science Foundation (NSF) in the 1990s (Sanders, 2009). Students today "will be required to exhibit understanding and skill that were unfathomable to us just twenty years ago" (Roberts, 2012, p. 4). It is important that students recognize how STEM fields and disciplines shape our

world (Bybee, 2010) and with the recommendations to integrate technology (and engineering) content into core subjects (Kuenzi, 2008), educators are tasked with a more integrative approach to education.

Inverted classrooms may be a contextual factor that has an impact on the levels of teacher efficacy within integrated STEM schools. Given the increasing attention on and implementation of classroom inversion, this researcher is interested in determining the effect inverted classrooms have on teacher efficacy. Provided the impact teacher efficacy has on student achievement (Cantrell, Young, & Moore, 2003), this researcher believes that studying the impact of inverted classrooms on teacher efficacy will add to the discourse in the field of educational practices in STEM curricula.

There is also evidence that the incorporation of technology into instruction provides for greater student engagement, especially with digital natives who are regularly immersed in technology as are the Millennial generation (Devlin, Feldhaus, & Bentrem, 2013; Prensky, 2001). This integration provides a framework for 21st-century student instruction that merits study into the effectiveness of such a framework with respect to student outcomes and achievement. Given the national attention paid to the constructs of inverted classrooms and STEM curricula, these phenomena merit study into their effectiveness toward teacher efficacy and student success.

Determining methods of instruction that more effectively reach and engage modern students with the use of digital tools may serve to improve the overall quality of education in STEM fields (Devlin et al., 2013; Prensky, 2001). Modern students, many of whom are

digital natives, may work and learn better in these digital environments (Prensky, 2001). As teacher efficacy is a factor of student achievement (Cantrell et al., 2003), determining the effect inverted classrooms have on teacher efficacy may serve to identify factors that will positively impact student achievement.

Purpose

The purpose of this research is to determine the effect inverted classrooms and curricula have on teacher efficacy. This research will also gauge the perceptions of inverted classrooms held by STEM teachers.

Research Questions

1. What are STEM teachers' perceptions of inverted classrooms?
2. How do STEM teachers' perceive the use of inverted classrooms and their ability to teach in an inverted classroom environment through the lens of teacher efficacy, and the four factors affecting that construct?

Limitations of the Study

1. This study will only be conducted in one high school.
2. The study will have a sample size of three teachers.
3. The study will look qualitatively at the efficacy of three STEM teachers, but will not draw comparisons to other teachers in non-inverted environments.
4. Researcher's bias may influence participants' responses during semi-structured interviews.

Methods Used in This Study

This study used phenomenological reduction to examine the "essence" of STEM teachers' perceptions of inverted classrooms through the lens of teacher efficacy (Creswell, 2007). Semi-structured interviews were recorded and transcribed. These transcriptions were then coded using In Vivo or "literal" coding and those codes were formed into narratives for each participant based on the four factors effecting teacher efficacy, experience, vicarious experience, social persuasion, and physiological factors (Hoy, 2000). These narratives were reduced into composite descriptions of all three participants and combined with a structural description of the school environment to determine the "essence" of the participants' perceptions of the inverted classroom environment.

Definitions

The following are the conceptual or operational definitions for the terminology used in this research:

Educational Technology – "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (Richey, 2008, p. 24).

Instructional Technology – the use of technology as a tool that enhances teaching and learning; teaching using technology (Dugger & Naik, 2001).

Inverted Classroom – also termed the "flipped classroom," this practice takes content and events traditionally given in the classroom and transfers them to outside the classroom and vice-versa (Lage et al., 2000).

Outcome Expectancy – the outcomes expected due to a particular behavior and dependent on a person's efficacy beliefs; can include social, physical, and self-evaluative outcomes (Anderson, Winett, & Wojcik, 2007).

Self-efficacy – belief in a one's ability to accomplish a task or reach a goal; affected by four factors: (a) personal/mastery experience; (b) vicarious experience; (c) social persuasion; and (d) physiological factors (Bandura, 1995; Ormrod, 2000).

Social Cognitive Theory – "a learning theory that proposes that portions of an individuals' knowledge acquisition can be directly related to observing others within the context of social interactions, experiences, and outside media influences" (Bardach, Gayer, Clinkinbeard, Zanjani, & Watkins, 2010, p. 409).

STEM – an acronym for Science, Technology, Engineering, and Mathematics (Bybee, 2010).

Teacher Efficacy – "the extent to which the teacher believe[s] he or she [has] the capacity to affect student performance" (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977, p. 137).

Summary

Classroom inversion may be a contextual factor impacting STEM teacher efficacy levels. This study sought to view three STEM teachers' perceptions of inverted classroom

through the lens of teacher efficacy. To accomplish this, the researcher used phenomenological reduction to determine the “essence” of the study participants’ experience using the inverted classroom instructional model. This research adds to a limited body of research, with respect to inverted classrooms, a framework for better understanding the inverted classroom and its impact on teacher efficacy.

CHAPTER 2: LITERATURE REVIEW

Introduction

The purpose of this research is to determine the effect inverted classrooms and curricula have on teacher efficacy. The literature contends that teacher efficacy is context and subject dependent (Tschannen-Moran & Hoy, 2001). As such, this chapter seeks to identify the literature with regard to teacher efficacy and the manner in which inverted classrooms are a contextual factor that affects teacher efficacy in STEM classrooms. While the study was limited to a single school and not generalizable to the entirety of inverted classrooms, the review of the current literature is meant to frame the phenomenon of inverted classrooms in STEM content environments.

Teacher Efficacy

Modern iterations of teacher efficacy are situated in social cognitive theory (SCT) (Dellinger, Bobbett, Olivier, & Ellett, 2008) and is generally defined as "the extent to which the teacher believe[s] he or she [has] the capacity to affect student performance" (Berman et al., 1977, p. 137). While outwardly similar to Bandura's (1977) theory of self-efficacy, where the focus lies on the outcomes for oneself, teacher efficacy is measured in the belief in the ability to influence the outcomes of others (Hoy, 2000). Common to modern discussions of both teacher efficacy and self-efficacy are four factors affecting both constructs: experience, vicarious experience, and social persuasion, and physiological factors (Bandura, 1977; Protheroe, 2008).

There is some recent discussion into the original basis of the theory and measurement of teacher efficacy and whether it is situated in Bandura's (1977) theory of self-efficacy or Rotter's (1966) locus of control and made to fit Bandura's work (Dellinger et al., 2008). What is clear from the existing literature is regardless of the rationale surrounding the initial instrument development (used by Armor et al. (1976) and Berman et al. (1977)), Bandura's theory of self-efficacy is the theory in which modern (post-1977) research and instrument development are grounded (Dellinger et al., 2008; Klassen, Tze, Betts, & Gordon, 2011)

Teacher Efficacy Conceptualization

Teacher efficacy as a construct is largely derived from two RAND Corporation studies on innovative educational programs (Armor et al., 1976; Berman et al., 1977; Hoy, 2000). These studies asked two questions with respondents answering using a 5-point Likert scale: (a) "When it comes right down to it, a teacher really can't do much because most of a student's motivation and performance depends on his or her home environment," and (b) "If I try really hard, I can get through to even the most difficult or unmotivated students" (Hoy, 2000, p. 7). These foundational studies were the basis for the conceptualization of several theories and titles for teacher efficacy including teacher efficacy, teaching efficacy, personal teaching efficacy, general teaching efficacy, and teacher self-efficacy (Hoy, 2000).

Measurement

Several instruments were also developed in an attempt to measure what Tschannen-Moran and Hoy (2001) termed as "an elusive construct." These instruments have evolved as

the literature on teacher efficacy became more developed and enough data was collected to analyze the validity of the instruments.

Gibson and Dembo (1984) developed a 30-item Teacher Efficacy Scale (TES) that attempted to improve the validity and reliability of the RAND Corporation survey instrument (Tschannen-Moran et al., 1998). A factor analysis identified two dimensions that Gibson and Dembo labeled *personal teaching efficacy* (measuring self-efficacy) and *teaching efficacy* (assumed to assess outcome expectancy) (Hoy, 2000) which Tschannen-Moran and Hoy (2001) later defined as general teacher efficacy (GTE) and personal teacher efficacy (PTE). In the discussion of their 1984 article, Gibson and Dembo contend that the construct of teacher efficacy is multidimensional and that "at least two dimensions correspond to Bandura's two-component model of self-efficacy" (1984, p. 579). These two dimensions are internal and external factors of outcome expectancy and were applied to the factors identified by Gibson and Dembo's analysis as well as by Tschannen-Moran and Hoy (2001) and Hoy (2000) even though the basis for the TES was the RAND Corporation instrument. The RAND Corporation instrument was based on Rotter's (1966) locus of control theory and Bandura's theory of self-efficacy was not mentioned in either study as a foundation for item development (Armor et al., 1976; Berman et al., 1977; Dellinger et al., 2008). Factor analysis of the 30-scale TES revealed some items loading on both factors (personal teaching efficacy and teaching efficacy) and was revised to include only 16 items that loaded uniquely on one of the two factors (Hoy, 2000; Soodak & Podell, 1993; Woolfolk & Hoy, 1990). This was

later reduced to 10 items in a (1993) study by Hoy and Woolfolk with five items in both personal and teaching efficacy (Hoy, 2000).

In response to what Dellinger et al. (2008) deemed inadequate measures of teacher efficacy (including the TES) the Teachers' Efficacy Beliefs System-Self Form (TEBS-Self), a 31-item instrument was developed to more accurately reflect Bandura's (1977) self-efficacy definition (Dellinger et al., 2008). Dellinger et al. (2008) found seven issues to be problematic in other instruments measuring teacher efficacy meant to be addressed by the TEBS-Self. Dellinger et al. (2008) acknowledge that the TES has addressed many of these issues (although do not specify which ones), but add that the TES instrument "was designed to, and appears to, measure *teacher self-efficacy beliefs* instead of *teacher efficacy*" (p. 755) and that the two terms are used synonymously.

Theoretical Framework

Social Cognitive Theory

Bandura's social cognitive theory explores the ways in which cognitive, behavioral, personal, and environmental factors interact and determine motivation and behavior (Crothers, Hughes, & Morine, 2008). Social cognitive theory suggests that parts of an individual's knowledge acquisition are influenced by social interactions, social observation, outside influences (media, etc.), and experience (Bandura, 1989; Bardach et al., 2010). While social cognitive theory provides various cognitive, vicarious, self-regulation, and self-efficacy components as roles in guiding psychosocial functioning (Lent, Brown, & Hackett,

1994), teacher efficacy, in modern iterations, aligns with the construct of self-efficacy (Dellinger et al., 2008; Hoy, 2000).

Behavior is frequently described as having unidirectional causation and shaped and controlled by either environmental influences or behavioral dispositions (Bandura, 1989). Social cognitive theory uses a model of triadic reciprocal determinism in which "behavior, cognition and other personal factors, and environmental influences all operate as interacting determinants that influence each other bidirectionally" (Bandura, 1989, p. 2) (Figure 2.2). These factors do not necessarily have equal influence and one may exert greater influence on behavior and motivation and factors and influences may not occur concurrently (Bandura, 1989).

Self-efficacy is identified as a personal factor of social cognitive theory and refers to a person's confidence in his or her ability to muster the requisite intrinsic resources necessary for successful task completion (Skaalvik & Skaalvik, 2007). The identification of self-efficacy as a personal factor within social cognitive theory is further supported by Bandura's characterization and reference to self-efficacy as "people's judgments of their capabilities…" (Bandura, 1986, p. 391) with those beliefs being central to the mechanism of personal agency (Bandura, 1989; Lent et al., 1994).

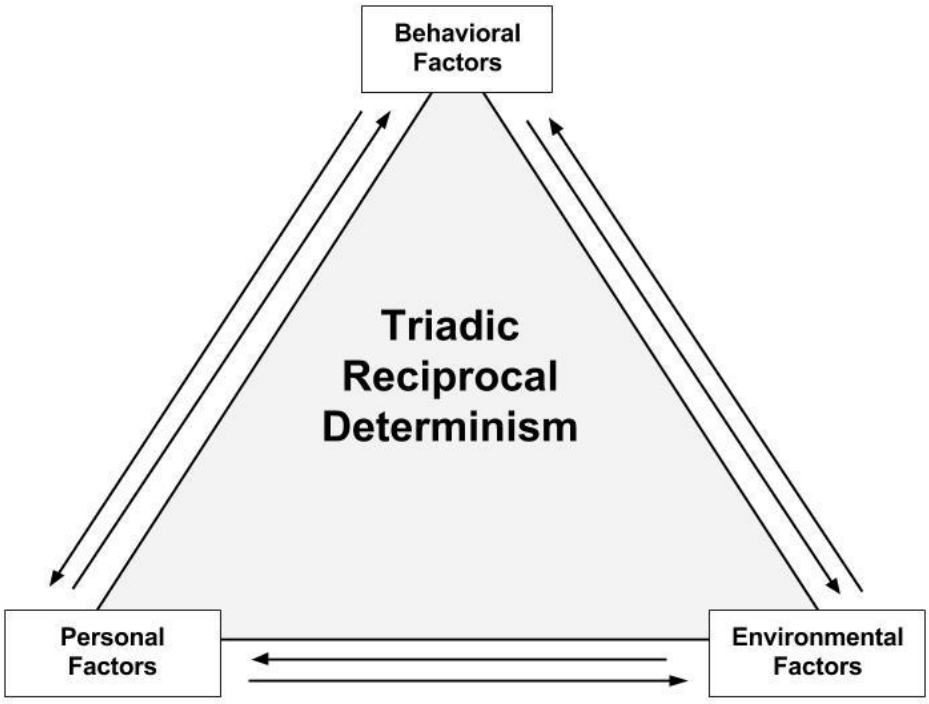

Figure 2.2 - Relationships between behavior, personal, and environmental factors for determining behavior and motivation - Adapted from Wood & Bandura (1989)

As discussed previously and as described in Dellinger et al. (2008), both studies by the RAND Corporation, forming the seminal basis for teacher efficacy construct definitions and research, were explicitly based in Rotter's (1966) locus of control theory. Dellinger et al. (2008) indicate "Bandura's self-efficacy theory was not mentioned" (p. 752) in the RAND Corporation studies as a foundation for the development of the instrument used.

Berman et al. (1977) stated "The standard discussion of efficacy, on which we based our instruments, is in. J. B. Rotter, '*Generalized Expectancies for Internal Versus External Control of Reinforcement*'" (p. 137). Rotter, not Bandura, is also referenced in Armor et al.

(1976). It is important to note that the basis for the initial research into teacher efficacy was not based on Bandura's theories of social cognition or self-efficacy, but on Rotter's work. The research since has been aligned with Bandura's theory including Dellinger et al. (2008), who pointed out the discrepancy, "The definition used to develop the TEBS-Self accurately reflects Bandura's (1977) original definition of self-efficacy" (p. 751).

Self-Efficacy

Seminal and foundational research into teacher efficacy was not grounded in Bandura's theory of self-efficacy, however, the research and theoretical frameworks of studies since have aligned with self-efficacy (Dellinger et al., 2008). There are differences as well when discussing outcome expectancy as teacher efficacy is dependent on the outcomes of others (Tschannen-Moran et al., 1998). However, self-efficacy discusses outcomes for self (Bandura, 1997). The similarities that exist between teacher and self-efficacy are the four factors that fundamentally affect them: (a) experience or mastery experience, (b) modeling or vicarious experience, (c) social persuasion, and (d) physiological factors (Bandura, 1995; Tschannen-Moran et al., 1998).

Mastery experience in the context of this research pertains to the successes and/or failures of the teachers' implementation of classrooms inversion or its components. The way in which mastery experience affects the teachers' efficacy is their preconception of their capabilities, perceived task difficulty, effort, and the teachers' perceived successes and failures (Bandura, 1997). In the context of this research, this may include technology use, student participation, and the time and effort needed to create online components of the

course. Perceived student mastery refers to the outcome expectancy component of teacher efficacy that differs from self-efficacy (Bandura, 1997; Tschannen-Moran et al., 1998).

This study investigates the effect of classroom inversion on teacher efficacy rather than self-efficacy. While differing constructs, it is important to point out the similarities in order to highlight nuanced difference between teacher efficacy and self-efficacy.

STEM Education

Originally called SMET by the National Science Foundation (NSF), the conglomeration of the disciplines of science, technology, engineering, and mathematics has been an emerging trend in education since the 1990s (Roberts, 2012; Sanders, 2009). STEM education offers an integrated approach to teaching these connected, but different subjects that offer students the ability to acquire knowledge skills and apply them to address new problems, often "real-world" in nature (Clark, 2012; Roberts, 2012). This approach allows students to work with STEM content in context and in an integrated manner (Breiner et al., 2012).

While an integrated approach is not always the standard in K-12 education, it is generally recognized as a goal (Breiner et al., 2012). A similar, but different, approach is the integrative STEM model where STEM subjects are taught in congruence by the same instructor or through collaborative instruction across disciplines (Sanders, 2009). While both these strategies appear to have merit, this research is focused on the STEM teachers themselves and does not address the methods by which STEM content is taught and integrated between disciplines.

Inverted Classrooms

The first mention of inverted classrooms appeared in the literature in a paper titled *Inverting the classroom: A gateway to creating an inclusive learning environment* (Lage et al., 2000). This was also the first research into classroom inversion and focused on student and faculty perceptions in an introductory economics course at Miami University. Simultaneously, Wesley Baker (2000) was presenting a theoretical model, *The "classroom flip": Using web course management tools to become the guide by the side,* in reference to Alison King's (1993) work. Baker's work is the start of the colloquial term "flipped classroom." Both define the inverted classroom similarly as "events that have traditionally taken place *inside* the classroom now take place *outside* the classroom and vice versa" (Lage et al., 2000, p. 32). Both papers stress that the advent of modern communication technologies and the Internet provide a platform for educators to present lecture material to students outside of the classroom, leaving greater time for discussion facilitation and active learning.

While the initial research by Lage et al. (2000) was grounded in accepted psychological and pedagogical theory, much of the encouragement toward inverting classrooms has been a grassroots, teacher-led movement. Organizations such as the Flipped Learning Network (flippedlearning.org) promote classroom inversion and provide resources for teachers interested in classroom curriculum inversion. Several books have been published and are promoted and sold by organizations such as The Flipped Learning Network and professional organizations such as the International Society for Technology in Education (ISTE). These books offer tips and advice to teachers wishing to "flip" all or some of their

classrooms. The most prolific authors of these books and the founding members of The Flipped Learning Network are Jonathan Bergmann and Aaron Sams.

Bergmann and Sams (2015; 2014; 2012) are classroom teachers who shared their experiences "flipping" their own classes and provide anecdotal evidence regarding the success experienced in their instructional methods. This success is generalized and offered as a model of how to invert a classroom and offered as evidence given to encourage others to invert their classrooms. Bergmann and Sam's first book *Flip your classroom: Reach every student every day* (2012) offers no citations of any kind to back up the claims made nor that classroom inversion is based in accepted theory. They do make a case for master-based learning, but offer no research-based methods.

Kathleen Fulton's *Time for learning: Top 10 reasons why flipping the classroom can change education* (2014) offers a chapter titled "Flipping is Grounded in Learning Theory," however, the chapter offers no empirical or theoretical research discussing flipped classrooms. Instead the text offers the writings of a blogger (p. 42) as the foundation for the chapter's main topic. The refereed research cited in the chapter speaks to the benefits of peer-instruction and constructivism, but offers no literature towards a learning theory in which flipped classrooms are based.

The books mentioned, as well as several others, present practical advice that may help teachers to implement new methods of instruction in their classrooms to improve student engagement and learning. Books and articles that aid teachers bringing new techniques into the classroom are valuable and teachers often bring new ideas into the classroom based on

vicarious experience (Kelly, 2015; Wagler, 2011). However, these anecdotes and small-scale successes do not inform the academic sphere of research and do not necessarily warrant the elevated status that inverted classrooms have enjoyed.

While research at the K-12 level is still sparse, there is a growing body of academic and empirical research into the impact on inverted classrooms on student achievement (Bishop, 2013; Overmyer, 2014; Schwankl, 2013). The bulk of these studies have been at the college level and have been represented by convenience samples comprised of the courses the professors' studying the phenomenon of inverted classrooms in their own courses (Conner et al., 2014; McGivney-Burelle & Xue, 2013).

A meta-analysis of the literature through 2012 was conducted by Jacob Bishop and Matthew Verleger (2013) found 24 studies related to inverted classrooms. They concluded that only one examined student performance for the duration of a course and included control and treatment groups. Bishop and Verleger (2013) concluded that this study was not generalizable and that "additional research is needed to examine the influence of flipped classroom instruction on objective learning outcomes."

Several studies have since been carried out that empirically study the effect of inverted classrooms. A 2013 study involving an undergraduate calculus course found that there was a relative increase in the test scores of the treatment group of students in an inverted classroom (n=31) over the scores in the control class (n=29) (McGivney-Burelle & Xue, 2013). The authors also reported students in the treatment group had higher levels of engagement with the material and a preference to having the class time available to work on

problems and ask questions. The authors generalize the study to other STEM fields and do not address any limitations of the study other than to state that a focus group of students who volunteered to participate in an interview was small. The paper offers justification and tips rather than an objective view of the phenomenon and its impact on student achievement.

A two-year study was conducted in an upper-division engineering course with the expressed intent to compare content coverage, student performance, and student perceptions (Mason, Shuman, & Cook, 2013). The study found the inverted class (n=20) a full week ahead of the traditional class (n=20) by the conclusion of the 10-week quarter, covered two additional topics, and was able to complete four design challenges compared to one by the traditional class (Mason et al., 2013). Students preferred the inverted instruction as they felt it "was a better use of class time and that the format better prepared them for engineering practice" (Mason et al., 2013, p. 433). Students in the inverted class performed better on assessments, but that is skewed by the contribution of a few problems effecting examination performance. The authors found that the inverted instruction "at best improved students' understanding of engineering concepts, and at worst 'did no harm'" (Mason et al., 2013, p. 433).

Student perceptions were measured in a qualitative study of an inverted agricultural methods course (Conner et al., 2014). In this study, 32 students were separated into two groups comprised of college juniors (n=17) and seniors and graduate students (n=15). Students offered mixed opinions of the inverted methods. Online videos were generally received positively, but there appeared to be some implementation issues including poor

audio/video quality in the online components, inadequate or inappropriate in-class activities, and "inconsistencies in [teaching assistant] performance" (Conner et al., 2014, p. 74).

A 2014 paper studied academic outcomes in three sections of an Introduction to Business Administration course (Findlay-Thompson & Mombourquette, 2014). Two sections of the course (n=42; n=36) were taught using traditional lecture-based instruction and one section (n=30) was inverted. Contrary to the researchers' expectations, there was no differences in grades when the inverted and traditional sections were compared (Findlay-Thompson & Mombourquette, 2014). The conclusions indicate that student buy-in is a requirement for successful implementation as is instructor's willingness to abandon traditional teaching methods and be trained in classroom inversion (Findlay-Thompson & Mombourquette, 2014).

No differences were found in either student performance or satisfaction in a study of an inverted neuroanatomy course (Whillier & Lystad, 2015). A treatment group (n=29) was compared to a control group (n=35) and the mean grade-point average for each group was identical at 2.24 (Whillier & Lystad, 2015).

Two other papers (Fulton, 2012; Overmyer, 2014) offer observations and reflections on the authors' experience inverting a math content course for pre-service teachers and an information systems course respectively. These papers offer no empirical data or results.

The papers since 2012 reviewed here, all speak to inverted classrooms at the post-secondary level, but scholarly research into the effectiveness of inverted instruction at the K-12 level is non-existent. Prior to 2012, only one experimental study that examined student

performance over an entire semester was conducted (Bishop & Verleger, 2013). The literature surrounding the phenomenon of inverted classrooms is sparse. The scarcity of post-secondary research and non-existence of K-12 study presents a demonstrable need for study into a phenomenon that is growing in popularity among educators and administrators.

Summary

Teacher efficacy, while similar to Bandura's (1977) theory of self-efficacy, diverges from that construct when discussing outcome expectancy. While determined to be "elusive" by some (Tschannen-Moran and Hoy, 2001), teacher efficacy is the extent to which the teacher believes he or she can impact student learning (Berman et al., 1977). While not originally aligned with the tenets of self-efficacy, current trends in teacher efficacy research have moved toward a more common structure between the two constructs (Dellinger et al., 2008).

Inverted classrooms where traditional lecture-based instruction is delivered outside the classroom leaving class time for greater levels of teacher facilitation (Lage et al., 2000), is a growing trend in both K-12 and post-secondary levels of education. While this method of instruction is increasing, research on its effectiveness is lagging behind especially in K-12 environments.

CHAPTER 3: METHODOLOGY

The purpose of this research is to determine teacher's perception of inverted classrooms and the effect inverted classrooms and curricula have on teacher efficacy. Teacher efficacy may be a factor affecting student learning and outcomes and serve as a predictor of teaching success and student achievement (Cantrell et al., 2003; Gibson & Dembo, 1984). As such, this research sought to understand teacher efficacy situated in the context of inverted classrooms.

Participants

Teachers from a local charter high school were selected both for the school's STEM focus and emphasis on inverted classrooms. The school's website states their mission "is to increase access to globally competitive Science, Technology, Engineering, and Math (STEM) education for students and teachers across North Carolina..." The school's homepage iterates "Our school is built around the 'flipped' model of education, in which teachers deliver content knowledge outside of class so that students can practice, apply, and build on what they have begun to learn." It is also required that all teachers "flip" the classroom and require a "flipped" lesson be demonstrated as part of the interview process.

The faculty participating in this research represented a convenient population for the researcher due to location and availability. The school was chosen due to several factors: (a) geographic proximity to the researcher's campus and residence to aid in meeting study participants for interviews, (b) the schools' stated focus on both inverted classrooms and STEM education, and (c) ability to control for different school climate concerns affecting

teachers' perceptions and teacher efficacy (Protheroe, 2008; Wagler, 2011). The school is also very open to educational research and makes teachers, students, and administrators available to researchers.

The school's staff directory was used to identify the STEM teachers and obtain contact information. Teachers representing three different STEM disciplines (technology education is not explicitly taught) were contacted via email (see appendix A). A voluntary sample of three teachers responded and agreed to participate in the study representing a 50% response rate. These teachers represented chemistry, environmental science, calculus, and engineering.

Exempt status was requested from the university's Institutional Review Board (IRB) and was granted (see appendix B). All participants were given and signed informed consent documents (see appendix C) after review with the researcher.

Research Questions

The purpose of this research is to determine teacher's perception of inverted classrooms and the effect inverted classrooms and curricula have on teacher efficacy. This inversion was a key component of the courses and curricula they instructed. The research questions for the study are as follows:

1. What are STEM teachers' perceptions of inverted classrooms?
2. How do STEM teachers' perceptions and/or use of inverted classrooms affect their teacher efficacy to teach in inverted classroom settings?

Methods

Semi-structured interviews were used as the method of data collection. The factors contributing to this determination include their suitability for perception exploration, their ability to probe for deeper understanding, and the varied professional experience of the participants disallowed a standardized question set (Barriball & While, 1994).

Interview Questions

Qualitative interview questions were developed for data collection based on the research questions. These questions were designed to be open-ended to as the participants own words were an essential component of this study (Fink, 2003). These questions were reviewed and edited by the researcher's committee chair and another faculty member both of whom have expertise in qualitative research and analysis. Consensus was achieved from both experts and the researcher. The following questions were asked of the study participants:

1. How would you define a flipped classroom?
2. Does using a flipped classroom affect your teaching various subjects? How so?
3. Is additional planning required to successfully implement a flipped classroom? If so, what is that planning time used for?
4. Have you completed any professional development regarding flipped classrooms? What professional development, if any, have you completed? What professional development did you find the most helpful? What professional development would you recommend for those implementing flipped classrooms?

5. Does the use of online lectures in a flipped classroom increase the level of student understanding of and/or engagement with the content?
6. What is your opinion of the educational value of flipped classrooms? Was your opinion different prior to teaching in a flipped environment?
7. What are the benefits of using a flipped classroom setting?
8. What are the drawbacks of using a flipped classroom?
9. Do you have all the resources needed to properly teach a flipped curriculum? What additional resources would you find helpful?

Procedure

The research is situated in the philosophical worldview of pragmatism whereby the concern is the application and an emphasis on the research question in context (Creswell, 2013). Researchers holding this worldview are not committed to a particular reality or system of philosophy and are therefore "free to choose methods, techniques, and procedures that best meet [the research's] needs and purposes" (Creswell, 2013, p. 11).

A qualitative study was determined to be the most viable way to examine perceptions of teachers using inverted classrooms and allow for the emergence of unique themes and issues. Five qualitative approaches were examined to determine the most suitable approach for this study.

The approaches examined were: (a) ethnography, (b) grounded theory, (c) case study, (d) narrative research, and (e) phenomenology. Ethnography was eliminated do to the use of observations over an extended period of time (Creswell, 2013). Grounded theory was

rejected because it required multiple stages of data collection and the use of different groups (Creswell, 2013). Case study did not fit as an approach due to the need for sustained data collection over a sustained period of time nor was a narrative research approach as it is better suited to the study of the participants' lives (Creswell, 2013).

It was determined that a transcendental phenomenological approach was the most appropriate approach for this study due to several reasons. The approach in this research involved studying a small number of participants, and the researcher deemed it appropriate to study the phenomenon as it was experienced by the participants as their perceptions were being analyzed (Creswell, 2013). Transcendental phenomenology considers the experience of each participant as a unique occurrence (Moustakas, 1994). Those experiences are combined and reduced to derive the "essence" of the phenomenon as experienced by the participants (Creswell, 2007; Moustakas, 1994). Phenomenological research aims to discover and define how individuals or groups experience a particular phenomenon (Vagle, 2014). The intent is not to understand how a study participant feels about a phenomenon, but rather the manifestation and appearance of it in the participants life and, in this case, work (Vagle, 2014).

Interview questions were generated around two general questions related to the study of the phenomenon: (a) What have participants experienced in terms of inverted classrooms? and (b) What has influenced or affected the participants experience with inverted classrooms? (Creswell, 2007). The term "flipped" was used in place of inverted as the more colloquial descriptor.

Participants were selected from a convenience population of STEM teachers in a local charter high school. All targeted teachers were sent an email (see appendix A) explaining the purpose of the study and requesting their participation. Several teachers agreed to participate and arrangements were made to interview them.

Participants met with the researcher in locations of their choosing and were interviewed after the study was explained to them and informed consent forms were signed. Semi-structured interviews were conducted and digitally recorded.

Data Analysis

Much of the analysis procedure came from the steps described by Creswell (2007) and Moustakas (1994). These books formed the foundation from which the process of phenomenological analysis was performed. The process used was as follows:

1. Organization and data preparation,
2. General understanding of all data,
3. Coding,
4. Textural and structural descriptions,
5. Composite description,
6. Qualitative narrative, and
7. Interpretation.

A third party transcribed digital recordings of the interviews and those transcriptions were checked and corrected by the researcher (see appendices D, E, & F). The documents

containing the interview transcriptions were imported into qualitative analysis software to be coded.

In Vivo, or literal, coding was selected for use in this study because it is an appropriate method for practitioner research (Saldaña, 2012). In Vivo coding is also "appropriate for virtually all qualitative studies, but particularly for beginning researchers learning to code data" (Saldaña, 2012, p. 91). A goal when using In Vivo coding is to frame the researcher's interpretations of participant's use of terms they use in everyday life as opposed to academic or professional jargon (Saldaña, 2012; Stringer, 1999, 2013).

The researcher coded literal words and phrases from the transcriptions for each participant that appeared to hold significance as to how the participants experienced the phenomenon (see appendices M, N, & O) (Creswell, 2007; Moustakas, 1994; Saldaña, 2012). This step is also referred to as *horizontalization (*Creswell, 2007; Moustakas, 1994). These codes were then developed into four themes based on Bandura's (1995) factors affecting self-efficacy (see appendices G, H, & I). These codes were only coded by the researcher rather than having multiple raters as interrater reliability is not common to phenomenological studies (De Wet & Erasmus, 2005). Multiple methods of validation were used including triangulation, clarifying researcher bias, and member checking (Creswell, 2007).

Once all participant interviews were coded and themes developed, textural descriptions of how each participant experienced the phenomenon were developed as it related to each theme (Creswell, 2007). These descriptions were sent to study participants (member checked) to ensure they accurately described the participant's experiences using the

inverted classroom model as it related to the four factors affecting teacher efficacy (Creswell, 2007).

These textural descriptions were condensed into a composite textural description (see appendix J) of how the phenomenon was experienced by each participant (Creswell, 2007). A summary of the researcher's experiences was written (see appendix P) to encapsulate the contexts, situations, and potential bias of the researcher's experience of the phenomenon (Creswell, 2007; Moustakas, 1994).

The researcher wrote a structural description (see appendix K) of the environment in which the participants teach (Creswell, 2007; Moustakas, 1994). This included school demographic information, mission, STEM focus, and required use of the inverted classroom methods of instruction. Phenomenological studies often have separate structural descriptions for each participant and a composite description of the participant structural descriptions is written (Creswell, 2007; Vagle, 2014). This was forgone in this study as the school environment was identical for all study participants and individual classroom differences were not observed.

From these composite descriptions a final composite description, or "essential description," was generated (see appendix L) (Creswell, 2007; Moustakas, 1994). This description captures the essence of the phenomenon as commonly experienced by the participants (Creswell, 2007; Moustakas, 1994).

Theme Generation

Themes were generated based on the four factors affecting teacher efficacy: experience, vicarious experience, social persuasion, and physiological factors (Bandura, 1977; Protheroe, 2008). Codes generated from participant interview transcripts were sorted into one of these categorical themes.

Experience. The perception by the teacher that his or her actions have been successful is directly proportional to efficacy beliefs (Hoy, 2000). Codes that related directly to the experience of the participants were categorized as experience. These included codes related to classroom inversion, technology use, success and/or failure with the inverted format, time gained in class, and reports of student experience.

Vicarious Experience. When a skill is demonstrated by another with whom the observer identifies, efficacy expectations increase or decrease in proportion with the models performance (Hoy, 2000). Codes that related to the experience of the students or other educators were categorized as vicarious experience. These included codes related to student observation, perceived student understanding of material and use of inverted format, success and/or failure of other teachers with the inverted format and technology use, and perceptions of student experience.

Social Persuasion. Performance feedback and the general discussion of others play a role in the level of efficacy experienced by the teacher (Hoy, 2000). Codes that related to professional development (both formal and informal), support and resources provided by the

school and its administrators, and the atmosphere/climate of the school regarding inverted classrooms were categorized as social persuasion.

Physiological Factors. Levels of physiological and emotional arousal contribute to a teacher's self-perception of teaching competence (Tschannen-Moran et al., 1998). Codes that related to the amount of extra time needed for classroom inversion (considered a stressor for this study) were categorized as a physiological factor.

Summary

This research used transcendental phenomenological reduction to examine how three high school teachers experience the inverted classroom method of instruction. The methods described in this chapter are designed to provide the reader with a sense of what it is like for the participants to experience the phenomenon (Creswell, 2007). The phenomenological research approach does not explain the phenomenon itself, but rather the way in which it is experienced (Creswell, 2013). The methods used took a raw transcript of interviews and a description of the environment in which the phenomenon is experienced and condenses them down to a short description of how the participants experience inverted classrooms as viewed through the lens of teacher efficacy. The participants' responses to interview questions were coded and categorized based the four factors effecting teacher efficacy: experience, vicarious experience, social persuasion, and physiological factors.

CHAPTER 4: FINDINGS

This study followed the steps for transcendental phenomenological reduction described by John W. Creswell (2007) and largely based on the work of Clark Moustakas (1994). This involved compiling descriptions of the participants' experiences of the phenomenon as they pertained to the four factors affecting teacher efficacy (Creswell, 2007). Individual descriptions were then combined and integrated with a structural description of the school environment (Creswell, 2007). This composite description reduced the experience to its essential components so the "essence" of the experience of the phenomenon could be realized (Creswell, 2007).

Participants

The participants in this study comprised of three high school teachers, who represented the subjects of environmental science, chemistry, and calculus. Participants had teaching experiences ranging from three years to more than 20. Experience with classroom inversion varied from two to four years. Study participants volunteered by responding to an email request sent to all STEM teachers in the school selected for study.

Setting

A suburban North Carolina public charter high school was chosen for this study because of its focus on both STEM and inverted instructional practices and the proximity to the researcher's home and university. The school has been in operation for three years and had an enrollment level of 341 students serving grades 9-11 at the time of this study. The average classroom had 24 students with ethnic demographic breakdowns being 54% White,

26% Black, 8% Asian, 6% Hispanic, 6% other/multi-racial. Twenty-two percent of students qualified for the federal free or reduced lunch program.

Inverted instruction is required of all teachers and a demonstrated inverted lesson is required for hire by the school. The school places an emphasis on ensuring teachers have all the needed resources available for the satisfactory inversion of classrooms. This includes technological resources (hardware and software), professional development, and in-house technical staff. The school follows a bring-your-own-device (BYOD) model for student computer technology use. Students without their own devices may use loaner computers provided by the school. Students with no or limited Internet access are also provided time before, during, and after school to access online class resources.

The Phenomenon of Interest

The purpose of this research is to determine teacher's perception of inverted classrooms and the effect inverted classrooms and curricula have on teacher efficacy. Participant experience was viewed through the lens of teacher efficacy and the factors that affect this construct (experience, vicarious experience, social persuasion, and physiologic factors).

Inverted Classroom Definition

All three study participants held similar working and operational definitions of inverted classrooms. Video recorded lectures were given to the students for viewing outside of the classroom. Class time was then used for hands-on activities, labs, working out problems, and/or working toward deeper understanding. This is consistent with the definition

originally posited by Lage et al. (2000) as a practice that takes content and events traditionally given in the classroom and transfers them to outside the classroom and vice-versa. This is the definition the researcher also used in this study.

Results

Transcendental phenomenological reduction resulted in the following composite description encompassing the "essence" of the participants' experience of the phenomenon. The phenomenon of inverted classrooms was viewed through the lens of teacher efficacy. The participants' experience was categorized into the four factors affecting teacher efficacy: experience, vicarious experience, social persuasion, and physiological factors. Direct participant quotes have been provided within the narrative to provide emphasis.

Theme 1: Experience

Teachers are required to invert instruction and come to the school with varying levels of experience. While teachers may begin with some skepticism or prior failure with respect to classroom inversion, the school environment provides the resources necessary for successful implementation. Classroom inversion is a major focus of the school and required of all its teachers. A requirement of employment is a demonstrable inverted lesson. As such, resources are made available to teachers, and an environment of collaboration is fostered within the school.

With classroom inversion, teachers reported having more class time available for the students to work through projects and tasks, and the teacher is more available for direct

student interaction and assistance. This allows teachers to create a deeper understanding of the topics and concepts in the students.

While teachers did spend greater amounts of time outside of class for video creation and editing, they reaped the rewards from that time spent in the first year of teaching a course in having a ready-made library for subsequent years. The teachers felt that in subsequent years of teaching the same course that initial time investment "becomes a real time saver" by having a ready-made library at their disposal.

Students are able to "go back and re-watch" prepackaged lectures. Students are also able to review the lectures prior to taking a test and those absent from class are able to watch the lecture at home. More time is available for teachers to delve deeper into material and as a result, can cover more topics with time to review prior to final exams.

Less class time is wasted giving the lecture, managing behavior, and repeating content for students struggling with concepts and participants agreed that there was more time "as teachers to be there while students are working." Teachers also reported having a greater understanding of the misconceptions held by students that may have gone unnoticed in a traditional class format. Teachers are able to sit with the students as they incorrectly answer questions and address student conceptual issues in real-time, "clear[ing] up misconceptions immediately" rather than trying to determine the cause of the misconceptions post-hoc.

Teachers using inverted classrooms should design their course with that inversion in mind. Students must watch the video lectures at home for the classroom inversion to be

successful. Teachers should be cognizant of the appropriateness of the courses/students for which he or she wishes to invert the curriculum. The teacher should consider available resources, course goals and needs, and school support. Methods of student accountability for watching the videos are an important factor of success. Students who do not watch the videos tend to fall and stay behind, so incenting the students to participate is an important design consideration for inverted classrooms. The school provides support in this area by creating a culture where inversion is not just expected of the teachers, but of students (and parents) as well. Students without the necessary resources (accessibility, time, hardware) are provided those opportunities through loaner computers and time before, during, and after school.

Theme 2: Vicarious Experience

Students who are active participants in inverted classrooms have greater opportunities to work with and talk to other students rather than sitting and listening as a passive listener. Students are also able to re-watch videos if needed. In class, students can get assistance from teachers and students when faced with a task that presents a challenge or a struggle. It is important that students feel incented to watch the videos at home so they come to class prepared and for the teacher to hold them accountable. Accountability is emphasized because if students fall behind by not watching the videos, they have a difficult time catching up. School structures and resources are made available to give students every opportunity to meet the requirements and address the challenges of an inverted classroom.

Some teachers perceive deficiencies in their own technological skills and “cannot do the video editing that other people can do,” when creating videos. Some teachers felt videos

created by younger, more technologically literate teachers show higher levels of editing skill and effects. Those less experienced teachers still felt their videos were effective. Students do not "[pick] up as much information from" non-teacher-made videos. Teacher-made, rather than found videos, is an important component for the students, and this concept is supported and promoted by administration. Given the common construct of inverted classrooms throughout the school, collaboration between teachers helps them gain knowledge and confidence in their own pedagogy.

Theme 3: Social Persuasion

Teachers reported that professional development was a key component of successful classroom inversion. Professional development was provided by the school with regular professional development meetings in addition to as needed or requested meetings. Teachers rely on peer-to-peer guidance and informal discussions of experience rather than formal training, which is either limited or non-existent.

Teachers are able to "learn from other teachers," and while they may desire additional training into pedagogy and technical skills, teachers feel comfortable discussing their methods with each other. School administrators are supportive and ensure resources are available for successful classroom inversion. Teachers need only "ask for it, and it would happen." This includes equipment, training, and software. There is an atmosphere of support among teachers and administrators surrounding inverted classrooms.

Theme 4: Physiological Factors

Time is a consistent factor in courses with inverted instruction. Teachers gain more time in class by having the lecture component completed at home. However, video creation and editing is an additional strain on the teacher's time outside of class. "The first year is a huge, huge tax on your time" outside of normal classroom planning, as the teacher must create the videos used for class. Teachers save "class time, but… [lose] planning time." The additional time is a stressor on inverted classroom teachers, especially in their first year(s) of teaching in an inverted classroom format.

Summary

Participants reported largely positive results from the use of inverted classrooms. More time was available for students to work though problems and complete tasks and the teacher was more available to directly interact with students and address concerns. Teachers were better able to understand student misconceptions and address them in real time.

While video creation represented a significant tax on the teachers' time, in subsequent years of teaching the same course that initial time investment was repaid by having a ready-made library at their disposal. Teachers in this study felt that they were able to progress through content faster and more efficiently, leaving time at the end of the semester for review that was unavailable to them when teaching in a traditional classroom format.

Students became more active participants during class time and were able to watch the videos, pause, take notes, and rewatch at their own pace. However, students failing to

watch the videos were more likely to fall and stay behind. For this reason, it is necessary to incentivize students and communicate expectations from the beginning of the course.

While some teachers are perceived to be more skilled in video production, it is still better for students to view teacher-made videos rather than videos found online. Collaboration between teachers and support from administration provide higher levels of skill and confidence in both skill and pedagogy.

Professional development is a key component of the successful inversion of a classroom. This development does not necessarily come from formal sources, but rather from informal conversations with teachers using similar methods. School administrators play a vital role in the successful implementation of inverted classrooms by ensuring proper and functioning technology, professional development resources, and creating an atmosphere of support.

There are many factors directly impacting the successful implementation of classroom inversion. It is a delicate balance of factors that must focus on the success of the students rather than the use of a particular method of instruction. All stakeholders must take an active role for the inverted model to be viable and successful.

Teachers and administrators should take into consideration the time involved in planning and executing an inverted classroom. Time to plan, create, and edit videos takes up a great deal of time both inside and outside traditional school working hours. While this time is partially recouped in subsequent years, adding to and improving existing video catalogs should be accounted for.

Teachers should also communicate expectations to students at the outset of the course. Expectations and the incentivizing of student participation should be built into the course structure and not merely an ancillary component of class procedures.

Teachers should attend professional development, whether formal or informal, to learn new strategies and communicate their own methods of classroom inversion. This may lead to higher levels of teacher efficacy as they may see what other methods are being used in other environments.

CHAPTER 5: DISCUSSION

The use of the inverted or "flipped" classroom has been a growing trend in education since the term's insertion into the educational lexicon by Lage et al. (2000). Teacher efficacy was introduced with the release of two RAND Corporation studies by Armor et al. (1976) and Berman et al. (1977). Teacher efficacy may be a predictive factor for student outcomes (Cantrell et al., 2003). As such, this study sought to examine perceptions of classroom inversion through the lens of teacher efficacy among STEM teachers in a high school setting. There is a limited body of research on student outcomes resulting from inverted classroom instructional methods. Even smaller is the body of literature on inverted classroom use in K-12 settings.

This research is intended to add a possible framework that would more deeply analyze themes that contribute to the successes of teachers. Also important is gaining insight into factors that may contribute to teachers' inefficacious application of the inverted classroom model. With teachers often adopting a cycle of attempt, attack, and abandon (Kelly, 2015) understanding common issues (both positive and negative) encountered by teachers implementing inverted classrooms may lead to better teacher implementation and greater administrative support.

Two fundamental questions drove this research: (a) What are STEM teachers' perceptions of inverted classrooms? and (b) How do STEM teachers' perceive the use of inverted classrooms and their ability to teach in an inverted classroom environment through the lens of teacher efficacy, and the four factors affecting that construct?

The purposefully selected teachers in this study intentionally adopted an inverted classroom model. It could be assumed that if teachers were aware of the instructional method required in the school to which they were applying, they would have high levels of confidence to positively impact student and teacher success in the inverted classroom setting. The teachers are required to demonstrate an inverted lesson in order to apply for a position with the school studied. This process exemplifies at least some understanding of the process of inverting a course prior to accepting a position. However, the teacher interviewed in this study did not hold consistent initial views of inverted classrooms. One teacher had experimented with the format while another reported having no experience and was admittedly "skeptical" of the effectiveness of the approach. A third teacher had tried and failed to invert instruction in another classroom.

Regardless of the perceptions teachers held studied prior to their engagement in flipped classrooms, participants in this study perceived the use of the method to be largely positive. This includes increased time during class to cover material and address student misconceptions in real time. Student misconceptions also became clearer to the teachers using classroom inversion. Teacher perceptions of inverted classrooms ranged from positive to considering it "priceless" and revolutionizing their teaching.

The teachers perceived student use as a positive factor because students were able to stop and re-watch the video or sections of it. Students who were absent were able to stay abreast with respect to content delivery, and those wishing to review lectures prior to exams could revisit the online videos. A concern raised was that students neglecting to watch the

videos outside of class were more likely to get, and stay, behind. Other participants addressed this as a demonstrable need to incentivize students to actively participate in out-of-class activities and for class expectations to include that participation clearly from the outset of class.

The structure and resources of the participating school played a considerable role in the perceptions of the teachers' with respect to having all the training and support (both technical and professional) needed to successfully implement an inverted classroom. Teachers reported that they had all the needed resources, and any resources they felt were needed or warranted would be made available. The school also appears to promote discussion and collaboration among teachers, which may add to positive attitudes regarding the needed skills and end products of inverted instructional materials.

A common theme among all participants was time. While positive gains in classroom time spent with students and on curricula were reported, the extra time spent planning and creating online lectures was laborious. Teachers reported that preparing for an inverted course took more time especially in the first year of teaching the curriculum as an inverted class. Participants also reported that the time spent in the first year of a course was rewarded in subsequent years as a library of content was built. While videos covering course content is readily available online, it was the opinion of the participants that teacher-made videos were superior.

The STEM teachers interviewed for this study had high levels of observed teacher efficacy. These teachers did not come into their current positions and the inverted classroom

methods with the same attitudes and perceptions they held after teaching in inverted classrooms. The consensus among the three participants is that inverting the classroom positively impacts their teaching and students. Examining their perceptions of classroom inversion through the lens of teacher efficacy, and the four factors affecting that construct (Hoy, 2000), participants were mostly positive in all four areas. The factor with the greatest negative statements (time) was greatly mitigated by the ability to recoup that time in ensuing years.

Recommendations for Future Study

This study is limited in that it was conducted using only three teachers from one high school. The high school also places a high value on classroom inversion and necessary resources for teachers and students are provided. The study did not quantify teacher efficacy levels and served only to identify the factors within successfully inverted classrooms affecting teacher efficacy. Student perceptions were not considered except where teacher perceptions of student engagement and participation were concerned. Further research in schools without such a focus may give greater insight into how much school culture impacts successful implementation of inverted classrooms. Triangulation of qualitative and quantitative data may also lead to greater insight into the effect of the phenomenon on teacher efficacy. Additional research in schools outside of North Carolina as well as public (non-charter) schools may provide further insight on the inverted classrooms impact on teacher efficacy generally.

There is a dearth of literature representing K-12 student perceptions of inverted classrooms. Studies that seek insight into student attitudes and perceptions would give researchers a greater understanding into the true impact of inverted classrooms. Without such research, teachers and researchers alike can only draw conclusions and inferences into how inverted instructional methods are viewed from the classroom.

Conclusion

The purpose of this research was to determine teacher perception of inverted classrooms and the effect inverted classrooms and curricula have on teacher efficacy. This research is the first to attempt capture the essence of the inverted classroom phenomenon in the context of teacher efficacy which Tschannen-Moran and Hoy (2001) described as "elusive." Further studies are needed into whether inverted classrooms are effective in the K-12 arena and how to make them so. Classroom inversion is a method of instruction that will only increase in use with expanding access to technology and high-speed data connectivity. Understanding how to best implement classroom inversion is important if the goal is to provide the best educational methods and pedagogy possible to today's students.

As the inverted classroom model gains more attention as well as its use as a method of instruction, it is incumbent upon researchers and educators alike to determine the validity of such methods through the lens of student outcomes and achievement. While it is acknowledged by this researcher that student achievement is difficult to define as well as measure, finding methods that positively impact teaching and learning is of upmost importance. This study is intended to provide a framework for gaining insight into classroom

inversion. At a minimum, this researcher is optimistic that this study will prompt a dialogue about the successful implementation of inverted classrooms in K-12 education.

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APPENDICES

Appendix A: Email sent to potential study participants

Good morning,

I am conducting research into STEM teachers' perceptions of flipped classrooms as part of my Master's thesis in the Technology, Engineering, and Design department at North Carolina State University. I am asking for your participation in a qualitative research study in which I interview four teachers regarding their experiences and opinions of the flipped classroom environment.

Your participation is vital to the research surrounding flipped classrooms and their effectiveness. I hope you will consider taking the time to participate. The interview will last approximately 30 minutes. I know your time is valuable and I appreciate your consideration.

If you are interested and willing to participate or have any questions, please contact me at dpkelly@ncsu.edu. I would like to conduct the interviews during the first week of April.

Thank you,

Daniel Kelly

Appendix B: IRB Submission

NORTH CAROLINA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD FOR THE USE OF HUMAN SUBJECTS IN RESEARCH
SUBMISSION FOR NEW STUDIES

Protocol Number 5531

Project Title
STEM Teacher Efficacy in Inverted Classrooms

IRB File Number:

Original Approval Date:
03/09/2015

Approval Period
03/09/2015 -

Source of funding (if externally funded, enter PINS or RADAR number of funding proposal via 'Add New Sponsored Project Record' button below):
None

NCSU Faculty point of contact for this protocol:NB: only this person has authority to submit the protocol
Denson, Cameron DeLeon: Science, Technology, Engineering, & Mathematics Education (STEM)

Does any investigator associated with this project have a significant financial interest in, or other conflict of interest involving, the sponsor of this project? (Answer No if this project is not sponsored)
No

Is this conflict managed with a written management plan, and is the management plan being properly followed?
No

Preliminary Review Determination

Category:
Exempt b.2

Provide a brief synopsis of the study (limit text to 1500 characters)
The proposed study will investigate the effect teaching in an inverted "flipped" classroom environment has on the teacher efficacy of science, technology, engineering, and math (STEM) teachers. The research will include interviewing four teachers regarding their perceptions of inverted classrooms in STEM courses. The study will be conducted using local high school teachers and use questions designed to gauge their efficacy with respect to teaching their individual subjects using the inverted classroom model.

Briefly describe in lay language the purpose of the proposed research and why it is important.
This research is meant to study the impact of inverted classrooms on teacher efficacy. While the construct of teacher efficacy is well documented, research into inverted classrooms is remarkably lacking. This study adds to a limited body of research and will be the first to look at teacher efficacy in inverted classroom environments.

Is this research being conducted by a student?
Yes

Is this research for a thesis?
Yes

Is this research for a dissertatiion?
No

Is this independent research?
No

Is this research for a course?
No

Do you currently intend to use the data for any purpose beyond the fulfillment of the class assignment?
No

Please explain

If so, please explain

If you anticipate additional NCSU-affiliated investigators (other than those listed on the Title tab) may be involved in this research, list them here indicating their name and department.

Will the investigators be collaborating with researchers at any institutions or organizations outside of NC State?

No

List collaborating institutions and describe the nature of the collaboration

What is NCSU's role in this research?

Describe funding flow, if any (e.g. subcontractors)

Is this international research?

No

Identify the countries involved in this research

An IRB equivalent review for local and cultural context may be necessary for this study. Can you recommend consultants with cultural expertise who may be willing to provide this review?

Adults 18 - 64 in the general population?

Yes

NCSU students, faculty or staff?

No

Adults age 65 and older?

No

Minors (under age 18--be sure to include provision for parental consent and/or child assent)?

No

List ages or age range:

Could any of the children be "Wards of the State" (a child whose welfare is the responsibility of the state or other agency, institution, or entity)?

No

Please explain:

Prisoners (any individual involuntarily confined or detained in a penal institution -- can be detained pending arraignment, trial or sentencing)?

No

Pregnant women?

No

Are pregnant women the primary population or focus for this research?

No

Provide rationale for why they are the focus population and describe the risks associated with their involvment as participants

Fetuses?

No

Students?

No

Does the research involve normal educational practices?

No

Is the research being conducted in an accepted educational setting?

No

Are participants in a class taught by the principal investigator?

No

Are the research activities part of the required course requirements?

No

Will course credit be offered to participants?

No

Amount of credit?

No

If class credit will be given, list the amount and alternative ways to earn the same amount of credit.Note: the time it takes to gain the same amount of credit by the alternate means should be commensurate with the study task(s)

How will permission to conduct research be obtained from the school or district?

Will you utilize private academic records?

No

Explain the procedures and document permission for accessing these records.

Employees?

No

Describe where (in the workplace, out of the workplace) activities will be conducted.

From whom and how will permission to conduct research on the employees be obtained?

How will potential participants be approached and informed about the research so as to reduce any perceived coercion to participate?

Is the employer involved in the research activities in any way?

No

Please explain:

Will the employer receive any results from the research activities (i.e. reports, recommendations, etc.)?

No

Please explain. How will employee identities be protected in reports provided to employers?

Impaired decision making capacity/Legally incompetent?

No

How will competency be assessed and from whom will you obtain consent?

Mental/emotional/developmental/psychiatric challenges?

No

Identify the challenge and explain the unique risks for this population.

Describe any special provisions necessary for consent and other study activities (e.g., legal guardian for those unable to consent).

People with physical challenges?

No

Identify the challenge and explain the unique risks for this population.

Describe any special provisions necessary for working with this population (e.g., witnesses for the visually impaired).

Economically or educationally disadvantaged?

No

Racial, ethnic, religious and/or other minorities?

No

Non-English speakers?

No

Describe the procedures used to overcome any language barrier.

Will a translator be used?

No

Provide information about the translator (who they are, relation to the community, why you have selected them for use, confidentiality measures being utilized).

Explain the necessity for the use of the vulnerable populations listed.

State how, where, when, and by whom consent will be obtained from each participant group. Identify the type of consent (e.g., written, verbal, electronic, etc.). Label and submit all consent forms.

Written consent will be obtained from all participants.

If any participants are minors, describe the process for obtaining parental consent and minor's assent (minor's agreement to participate).

N/A

Are you applying for a waiver of the requirement for consent (no consent information of any kind provided to participants) for any participant group(s) in your study?

No

Describe the procedures and/or participant group for which you are applying for a waiver, and justify why this waiver is needed and consent is not feasible.

Are you applying for an alteration (exclusion of one or more of the specific required elements) of consent for any participant group(s) in your study?

No

Identify which required elements of consent you are altering, describe the participant group(s) for which this waiver will apply, and justify why this waiver is needed.

Are you applying for a waiver of signed consent (consent information is provided, but participant signatures are not collected)? A waiver of signed consent may be granted only if: The research involves no more than minimal riskThe research involves no procedures for which consent is normally required outside of the research context.

No

Would a signed consent document be the only document or record linking the participant to the research?

No

Is there any deception of the human subjects involved in this study?

No

Describe why deception is necessary and describe the debriefing procedures.Does the deception require a waiver or alteration of informed consent information?Describe debriefing and/or disclosure procedures and submit materials for review.Are participants given the option to destroy their data if they do not want to be a part the study after disclosure?

For each participant group please indicate how many individuals from that group will be involved in the research. Estimates or ranges of the numbers of participants are acceptable. Please be aware that participant numbers may affect study risk. If your participation totals differ by 10% from what was originally approved, notify the IRB.

Four teachers will be selected for participation in the study from a group of high school STEM teachers.

How will potential participants be be found and selected for inclusion in the study?

Participants will be selected based on their content discipline. On teacher from each of the four STEM fields will be chosen. The following email will be sent to teachers from the school selected for study:

â€œI am conducting research into STEM teachersâ€™ perceptions of flipped classrooms as part of my thesis in the Technology, Engineering, and Design department at North Carolina State University. I am asking for your participation in a qualitative research study in which I interview four teachers regarding their experiences and opinions of the flipped classroom environment.

Your participation is vital to the research surrounding flipped classrooms and their effectiveness. I hope you will consider taking the time to participate. The interview will last approximately 30 minutes. I know your time is valuable and I appreciate your consideration.

If you are interested and willing to participate or have any questions, please contact me at dpkelly@ncsu.edu.â€•

For each participant group, how will potential participants be approached about the research and invited to participate?

Total approached participants will be between 8 and 15 teachers. Teachers will be contacted via their school email addresses available on the schoolâ€™s website.

Describe any inclusion and exclusion criteria for your participants and describe why those criteria are necessary (If your study concentrates on a particular population, you do not need to repeat your description of that population here.)

The inclusion requirements require only that the teachers currently teach STEM content in a inverted classroom environment.

Is there any relationship between researcher and participants - such as teacher/student; employer/employee?

No

What is the justification for using this participant group instead of an unrelated participant group?

Describe any risks associated with conducting your research with a related participant group.

Describe how this relationship will be managed to reduce risk during the research.

How will risks to confidentiality be managed?

Address any concerns regarding data quality (e.g. non-candid responses) that could result from this relationship.

In the following questions describe in lay terms all study procedures that will be experienced by each group of participants in this study.For each group of participants in your study, provide a step-by-step description of what they will experience from beginning to end of the study activities.

Research subjects will participate in a qualitative interview that will be audio recorded. Subjects will be contacted and recruited via email.

Once the subjects are selected, convenient meeting times will be scheduled. The interviews will be conducted in person or via online videoconference.

Subjects will be sent the informed consent documents prior to the interview and will be explained, signed, and collected prior to any questions being asked.

Subjects will be asked the interview questions and follow-up questions as necessary.

Describe how, where, when, and by whom data will be collected.

The interviews will be conducted in-person (at the teachers' school, or via online video chat) at the convenience of the participant. These interviews will be recorded (audio only). All data will be collected by Daniel Kelly.

Social?

No

Psychological?

No

Financial/Employability?

No

Legal?

No

Physical?

No

Academic?

No

Employment?

No

Financial?

No

Medical?

No

Private Behavior?

No

Economic Status?

No

Sexual Issues?

No

Religious Issues/Beliefs?

No

Describe the nature and degree of risk that this study poses for each item marked "Yes" above. Describe the steps taken to minimize these risks. You CANNOT say 'none' or 'no risks'.

There is minimal risk associated with this research.

If you are accessing private records, describe how you are gaining access to these records, what information you need from the records, and how you will receive/record data.

Are you asking participants to disclose information about other individuals (e.g., friends, family, co-workers, etc.)?

No

Describe the data you will collect and discuss how you will protect confidentiality and the privacy of these third-party individuals.

If you are collecting information that participants might consider personal or sensitive or that if revealed might cause embarrassment, harm to reputation or could reasonably place the subjects at risk of criminal or civil liability, what measures will you take to protect participants from those risks?

If any of the study procedures could be considered risky in and of themselves (e.g. study procedures involving upsetting questions, stressful situations, physical risks, etc.) what measures will you take to protect participants from those risks?

Describe the anticipated direct benefits to be gained by each group of participants in this study (compensation is not a direct benefit).

There is no direct benefit for participation.

If no direct benefit is expected for participants describe any indirect benefits that may be expected, such as to the scientific community or to society.

Participation in the study will benefit the educational and research communities.

Will you be receiving already existing data without identifiers for this study?

No

Will you be receiving already existing data which includes identifiers for this study?

No

Describe how the benefits balance out the risks of this study.

The study adds to the discourse in the field of STEM education and educational practices with little or no risk to study participants.

Will data be collected anonymously (meaning that you do not ever collect data in a way that would allow you to link any identifying information to a participant)?

Yes

Will identifiers be recorded with the data?

No

Will you use a master list, crosswalk, or other means of linking a participant's identity to the data?

No

Will it be possible to identify a participant indirectly from the data collected (i.e. indirect identification from demographic information)?

Yes

Audio recordings?

Yes

Video recordings?

No

Images?

No

Digital/electronic files?

Yes

Paper documents (including notes and journals)?

Yes

Physiological Responses?

No

Online survey?

Yes

Restricted Computer?

No

Password Protected files?

Yes

Firewall System?

No

Locked Private Office?

No

Locked Filing Cabinets?

No

Encrypted Files?

No

Describe all participant identifiers that will be collected (whether they will be retained or not) and explain why they are necessary.

The content area in which the participants teach will be recorded as part of the study in order to identify content dependent differences in responses. The subjects will be identified as teaching a particular subject. Based on this information, it may be possible to determine the subjectâ€™s identity. This data and any data linking participants will not be retained.

If any links between data and participants are to be retained, how will you protect the confidentiality of the data?

If you are collecting data electronically, what (if any) identifiable information will be collected by the host site (such as email and/or IP address) and will this information be reported to you?

No identifiable information will be reported.

Describe any ways that participants could be identified indirectly from the data collected and describe measures taken to protect identities.

The content area in which the participants teach will be recorded, but their names will not be recorded.

For all recordings of any type:Describe the type of recording(s) to be made Describe the safe storage of recordings Who will have access to the recordings? Will recordings be used in publications or data reporting? Will images be altered to de-identify?Will recordings be transcribed and by whom?

Digital audio recordings will be taken and stored in a password protected file. Only the investigator will have access to the recordings.

Describe how data will be reported (aggregate, individual responses, use of direct quotes) and describe how identities will be protected in study reports.

Individual responses and direct quotes will be used, but participant names will be omitted from all data collection.

Will anyone besides the PI or the research team have access to the data (including completed surveys) from the moment they are collected until they are destroyed?

No

Describe any compensation that participants will be eligible to receive, including what the compensation is, any eligibility requirements, and how it will be delivered.

No compensation will be provided.

Explain compensation provisions if the participant withdraws prior to completion of the study.

Appendix C: Informed Consent Form

North Carolina State University

INFORMED CONSENT FORM for RESEARCH

STEM Teacher Efficacy in Inverted Classrooms

Principal Investigator: Daniel P. Kelly
Faculty Sponsor: Cameron D. Denson

What are some general things you should know about research studies?

You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

What is the purpose of this study?

This study will investigate the effect teaching in an inverted "flipped" classroom environment has on the teacher efficacy of science, technology, engineering, and math (STEM) teachers. The research will include surveying four high school teachers followed by interviews to compare the answers given in the survey. The study will be conducted using high school teachers from and use questions designed to gauge their efficacy with respect to teaching their individual subjects using the inverted classroom model.

What will happen if you take part in the study?

If you agree to participate in this study, you will be asked participate in an interview that will last approximately 30 minutes. The interview may be done in person or conducted online via Skype or similar software.

Risks

I do not anticipate any risks to you participating in this study other than those encountered in day-to-day life.

Benefits

There will be no direct benefit for participation in the study. However, your participation will benefit the study of inverted classrooms and teacher efficacy.

Confidentiality

The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely in password-protected programs. No reference will be made in oral or written reports which could link you to the study. You will NOT be asked to write your name on any study materials so that no one can match your identity to the answers that you provide.

Compensation

You will not receive anything for participating.

What if you have questions about this study?

If you have questions at any time about the study or the procedures, you may contact the researcher, Daniel Kelly, at dpkelly@ncsu, or 919.229.9167.

What if you have questions about your rights as a research participant?

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator at dapaxton@ncsu.edu or by phone at 1-919-515-4514.

Consent To Participate

"I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose not to participate or to stop participating at any time without penalty or loss of benefits to which I am otherwise entitled."

Subject's signature_____ **Date** _____

Investigator's signature_____ **Date** _____

Appendix D: Participant A Interview Transcription

[Interviewer: How would you define a flipped classroom?]

[Participant: A flipped classroom is where the instructional material is presented in videos that the students watch at home and in science the practice or the homework, the traditional homework, is completed in class. So doing problems that's done in class and of course labs and things are all done in the classroom. So, I think the word flipped came from what you used to do at school is what you are doing at home now and what you used to do at home, you're doing in school now. So, there's no content delivery during the class period.]

[Interviewer: None at all.]

[Participant: None at all.]

[Interviewer: Are the videos then online?]

[Participant: They are, on YouTube I have a channel, I also have a way to tell if they watched it, or pushed the play button, how long they watched it, when they watched, how many times they watched it. A lot of my students will tell me they will watch it, then we will do the class work the next day, and they'll go back and rewatch it and it makes so much more sense. So, it's like hearing the lecture twice.]

[Interviewer: Are those metrics through YouTube?]

[Participant: It's through Moodle}

[Interviewer: okay]

[Participant: You are familiar with Moodle.]

[Interviewer: Does using the flipped classroom affect your teaching?]

[Participant: The word revolutionized it probably the best word for it. It gives me so much more time in the classroom. So, what I have found, something that used to take me a class period to teach along with all of your other duties, like getting attendance, and classroom management, and stopping and answering questions as you go. I can make a 10-12 minute video that would have consumed an entire class period. There are a lot of times in the video where I tell them to stop the video and try this problem. And so, 12 minutes because they are stopping and doing a problem, but it just saves classroom time, in class I am watching students practice and make mistakes. And before I didn't always know what they were doing or how they were getting these wrong answers. You would test them and be like oh that's wrong or you know, I don't know what you did here. Now I'm sitting there while they are getting the wrong answers, and I am learning so much about misconceptions about, and I can clear them up immediately.]

[Interviewer: Now, do you make the videos?]

[Participant: I do. Every once in a while, our principal believes that there is some information they learn better from you as an instructor, every once in a while I will find a video that has great animation. I am not great, I cannot do the video editing that other people can do. I can deliver the content, but I can't make it fancy or have these great animations and

things happening. So every once and a while, If there is a video out there that has great animations and is correct I'll use that instead of my video. But I find they are not picking up as much information from that, they're being entertained. I guess I am using those videos for more of a visualization, to see stuff. So I make all my own videos.]

[Interviewer: Is additional planning then needed to flip the classroom?]

[Participant: My first year, so I have taught chemistry for about 20 years, and last year there were days when I was getting up at 4:00 to make the video, because I didn't have a library of videos to go to. So even though I knew the content, knew what I was going to be covering, even had some sheets that I was going to use in the class or the labs were prepared. Just making the videos were time consuming. So, the first year there is a lot, its very time consuming, but now I am reaping those benefits this year, and so I am able to make other videos this year that I wanted to make but couldn't make. But it's a lt. That first year was tough though. It was tough.

[Interviewer: Have you completed any professional development for flipped classrooms?]

[Participant: I have, I had a class from that gentleman from NC State who is big on the whiteboard flipping, I forget his name. He thinks that using the whiteboards are the most effective way for flipping. I went to one of his classes. I've done some online stuff, but then I just learned from the teachers here. Chemistry wasn't offered until their second year, so I

didn't come in until the school was in its second year, so I had teachers here who had done it for a whole year who could help me.]

[Interviewer: What PD did you find most helpful?]

[Participant: The workshops. Watching other people talk about flipping, what worked for them, what didn't work for them, and it is kind of content specific as well.]

[Interviewer: What would you recommend as far as professional development?]

[Participant: I think there is no better way to learn how to do it than to learn from someone that already has doing it in your content area. May not help me or another science teacher to watch an English flipped video because they're not solving problems or things like that. But I think in the sciences, watch a science teacher.]

[Interviewer: So for content area, the science disciple verses just chemistry.]

[Participant: Yeah]

[Interviewer: Has the use the of online lectures increase student learning or engagement of the content?]

[Participant: I think so, the problem is it's not a really good scientific measure because I taught at a private school before, this is a public charter. So, it's hard to compare when I wasn't flipping and when I was. But I had the students perform very well on their end

of grade test, I completed all the content and with time to review which I had never done before.]

[Interviewer: What about engagement?]

[Participant: I don't know about the engagement during the video process because I am not there, but I do watch them watch in seminar. But, in class it's nothing but engagement they work together with one another and I'm walking around, I rarely sit. Today, they watched a video last night on how to dilute solutions and use the M1V1 formula. So they are going to come in and it is pretty much standard routine, they do a warm up based on the night's video, and they have their notes out so they can use them to help, and then I can see. I'll say, "Oh you know you didn't watch you video? Well, you need to watch your video, you know, go watch it now." So it's kind of a way to keep them accountable. They are doing their warm up and I am taking attendance, then we go over it. So there is some instruction in that regard, like I'm doing another problem but it's very interactive. I I'm really able to tell if they understood the content or not, if the room is silent then no it didn't get through. If they are answering wrong answers we address misconceptions, and then it starts making them ask questions. I was worried about flipping because you miss the questioning that the students will do during lectures but you get that out of them the next day. So after the warm up, their project, I don't always do projects, but their project is to make a video about how to make a solution. I give them a card and I'm like you need to make a video about how to make this solution, And they have 2 days to make their video with their group and turn it in. And I have

had other classes already do this and it was awesome! I would never have the luxury of 2 days to let the kids make solutions it's all pretend, The bottles say six moles of sulfuric acid, but it's just water. But, they are going through the motions. I call it the next Chem Network Star like the next Food Network Star. There is a competition, first the science has to be right, and then I'm sending it to other faculty to judge who the next Chem Network Star is.]

[Interviewer: So what is your opinion then of the Educational value of the flipped classroom?]

[Participant: Priceless. I mean, you're talking to a teacher, I was very skeptical, Very skeptical. But I was so tired of not finishing content, also students are out they miss the content, now they don't miss the content. So, it's incredible.]

[Interviewer: That was my other question, how did you feel prior? Skeptical?]

[Participant: Skeptical, yeah.]

[Participant: Are you going to ask about any disadvantages?]

[Interviewer: Yeah?]

[Participant: Now?]

[Interviewer: Sure?]

[Participant: I just came to this conclusion about a month ago. The only disadvantage, and I can adjust my behavior to change this. They never struggle. Because the minute the

students start to struggle there might be someone at their table that can help them immediately, and that's good for the person who's helping because I think you really learn when you're teaching, or I come to the rescue. And, I think sometimes that solving that problem yourself there is a lot of learning that goes on. So when you're stuck at home doing your homework, but today with Snapchat and all these other everything, you know it's probably not, they're not going to sit there alone struggling anyway. But, I do sense that they are not problem solving for themselves as much as they used to. I can adjust that, I can change that. And I definitely use the Socratic method. I don't run up and tell them "you divide by... but I say, well, what information do you have?" I set up the scaffolding for them to get their answer, I'm not just answering it. But, I am able to back off on that a little bit.]

[Interviewer: What are your perceived benefits?]

[Participant: Benefits? Students tell me that they re-watch videos before tests so it's almost like hearing the lecture twice or going to class twice. So, they'll re-watch videos to relearn the content. It frees up that really valuable class time to do things that I think makes them understand the material better. Will they miss a dilution question on a test after spending two days doing this? I don't know, but it was fun. But also, I think it's just a more efficient use of time.]

[Interviewer: Do you have all the resources you need to properly flip the classroom?]

[Participant: I do. I had to learn, this did not come naturally to me. And our younger teachers, their videos are amazing, the video editing. The biology teacher, her videos are just… they're awesome. So for instance, talking about viruses in there, are they dead or alive? She comes out like a zombie at the beginning, "Am I dead or am I alive?" She is very engaging in her videos, and the content she delivers is awesome. I don't have the all the video… I just didn't have time for all that stuff either. But my content is delivered and the kids don't complain about it. All these different quality… but it's just me, talking over a PowerPoint.]

[Interviewer: Are there any additional resources that you would find helpful?]

[Participant: Knowledge. I need to learn how to do video editing. So many people come into this job already knowing how to do this stuff, I just did not. We weren't even allowed to have laptops in the classroom at my last school.]

[Interviewer: The students or the teachers?]

[Participant: The students. I actually wanted to flip some lessons for students going on a mission trip but the administration said no. I thought I needed to ask for permission. And they said no. They thought student engagement was really important. I didn't know how to do any of this before I came. It's crazy that I took this job, but I love it.]

Appendix E: Participant B Interview Transcription

[Interviewer: How would you define flipped classroom?]

[Participant: it's an environment where the majority of direct instruction occurs outside the classroom usually via video. That frees up time in the classroom to have more direct interaction between students and students and students to teachers, working on problem sets or more engaging activities than just classroom lecture.]

[Interviewer: Does using the flipped classroom affect your teaching? And how so?]

[Participant: It involves a little bit of coordination, because what I'll typically do, it varies by class, what I'll typically do is keep track of what I have I gone over in the video lessons as opposed to what I wanted them to cover in class. 'Cause usually I will try to expand on what I have gone over in the video lesson in class rather than just reiterate it. However, as I get in the higher levels, so I teach pre-calculus and calculus. In Pre-calculus I kind of record almost the entire lesson, as I would have given it in class. I calculus it's more of an introductory lesson in the flipped video and then the class becomes more of a dialogue. You know, I have to do it that way because I feel don't you can't teach calculus without that dialogue with the student which you can't do via video.]

[Interviewer: Is additional planning required to successfully implement the flipped classroom?]

[Participant: I wouldn't say addition planning, but there is additional outside of class time involved. When I say planning I mean just assembling what am I going to teach, what are the problem sets, and how am I going to assess it. The time to record the videos is significant and additional. The payback on it is in future years if I'm teaching the same course, reusing the same videos and then it becomes a real time saver.]

[Interviewer: You said in the future recording them would help you because it would save time. But if the standards or objectives change you would have to go back and re-record, is that correct?]

[Participant: That's Correct. Re-record some things. The standards will change but the a lot of the content remains consistent. It's just a different order of different courses. So generally. It's not going to be re-recording the entire course.

[Interviewer: Have you completed any professional development with regards to the flipped classroom?]

[Participant: I have not, nothing formal. I mean, we'll have chats and talks at school during PD time but no formal training.]

[Interviewer: Would you recommend professional development? And what kind if you would?]

[Participant: For somebody new to it yes, just because there are a lot of options on the technology and a lot of ways to do it. I have been doing it for 3 years now I think and it started as an experiment in my calculus class a few years ago, and you would think the learning curve and first of all from the technology point of view you have to figure out; okay do I want to do just a plain recording with a camera, how to store those recordings to make them accessible to students. As well as do I want to do a screencast or some other mechanism for recording the video and of course what hardware is required for that. From a logistics point of view, the teacher needs to go in from the start, making this part of the requirements of the class and in some way incenting students to partake in watching the videos. Because if you have a significant number of students that don't watch the videos then a flipped classroom, is just a waste of everyone's time because those that watched it are going to get a repeat or a rehash or the ones that didn't watch it are going to be completely lost. So it just takes some design and I have heard different ways that people do it, but students need to know they need to watch the videos is what it comes down to.]

[Interviewer: Do you find the use of online lectures increases the level of student understanding or engagement with the content?]

[Participant: Yes, because students come in with foundational skills I need to take it to the next step. So it's great... In the past I'd ask questions in class and get blank stares and now I get discussion because students have watched the videos and at least know what to

expect and what line of thinking we are going to be doing and they have some background knowledge.]

[Interviewer: What is your opinion of the educational value of the flipped classroom?]

[Participant: I think it's basically, what you're doing is taking time that students, especially in the math classroom. I call it the blank sheet of paper effect. When I do problems in class as a demonstration students look at it and may or may not write it down, but they look and they watch it happening and think "oh yeah, that makes sense, I understand that, I get it". But when they go home or outside of classroom and they attempt to do similar problems, and when you have that blank sheet of paper it's difficult to begin. So what can happen is, you go through a standard class, you do 20 problems, whatever it is, and the students go home and they're stuck. So now they have essentially accomplished nothing at home because there is nobody to ask, especially in the upper level math classes, students don't have resources available to them in most cases. So, with flipping, I can turn it around and deliver lecture materials to them, they can watch it as many times as they want, they can rewind it, they can find additional resources or I post additional resources. So they should have a greater opportunity to get the skills communicated, and then, when they're in class they get to practice, and if they have the blank sheet of paper effect in class then guess what, they have the whole class, their classmates are there and the teacher there to get the task done. So it wastes less time.]

[Interviewer: Was your opinion of flipped classrooms different prior to teaching in one different than it is now that you have used it?]

[Participant: When I first heard about it I didn't quite get it, then when I saw okay there could be some value in it I started it with my calculus class. The reason I did it was I thinking they were mature and would actually cooperate and do the stuff and it kind of has worked that way. The change in my opinion is that at the lower levels it wouldn't be as effective because students just wouldn't watch the videos but as long as the incentive structure is there then the resistance of the temptation to say okay five students out of 20 didn't watch the video last night so I need to reteach the lesson. Because, I think that is what makes students that watch the videos more vigilant to watch the videos because they are going to just come in and get the lesson anyways because it didn't give them any gain. Once it got past that, I think that I'm more effective in using the tool. I have changed my opinion of where to use the technique.]

[Interviewer: What do you find are the benefits of using the flipped classroom setting?]

[Participant: The benefits are that I have more direct interaction time with students. Instead of just spending most of my time up in the front of the room talking, I am spending more time walking around the room and sitting with students and working problems and going towards a deeper understanding.]

[Interviewer: And the drawbacks?]

[Participant: Drawbacks are, I'm spending a lot of time recording videos. This year has been a rough year, I started at a new school where everything is flipped, so I'm recording the entire pre-calculus course which I have never taught, the calculus stuff I had largely done so that was good, but its time consuming. I'm actually sitting here on my spring break, I have my pre-calc book in front of me and I'm planning recording a bunch of videos today.]

[Interviewer: You flipped for a couple years prior to moving to Research Triangle High school?]

[Participant: That's correct.]

[Interviewer: Okay.]

[Participant: I only flipped in the one class though, the calculus classes.]

[Interviewer: And now you flip in all of them?]

[Participant: I actually flipped… I have pre-calc and calculus and a couple sections of calculus which are flipped are flipped. and then I teach an introduction to engineering course which is not.]

[Interviewer: So you don't flip the engineering course.]

[Participant: I do not.]

[Interviewer: Is there a reason that you don't?]

[Participant: Mainly because most of the content in the course is collaborative, group work. Construction type projects where they're applying engineering skills to solve some problem, so it's very hands-on and I didn't feel that it made any sense at all to flip it.]

[Interviewer: Are you using any particular engineering curriculum?]

[Participant: No]

[Interviewer: Do you have all the resources you need to properly teach in a flipped classroom?]

[Participant: I have all the resources I think I need to do what I do. I have the hardware tools. I like screen casting, so I have Screencast-O-Matic, I've got the writing tablets so I can actually write my notes, I've software on the laptop that will present my material, and allow me to annotate it. I guess that's about it. There is nothing I am hoping to get in the future right now.]

[Interviewer: That was actually my next question.]

[Interviewer: Is there anything else as far as the flipped classroom that you feel might be important as far as what I am trying to do in my research?]

[Participant: Most importing thing is getting the buy in of the students. It has to be the core of the course, its what you do. You can't not do the homework, I'm asking you for 15 minutes of your time to watch the video and take notes that has to be done otherwise it really affects the environment for everybody.]

Appendix F: Participant C Interview Transcription

[Interviewer: How would you define a flipped classroom?]

[Participant: Where the content delivery or like the lecture part of the class is delivered at home either by video or readings. And then, in class time is spent with students are actively participating with the information whether that's in the lab or some sort of group work or practice problems.]

[Interviewer: How does using a flipped classroom affect your subject?]

[Participant: I think it is great for science because it gives us the whole class period for labs and it also allows time as teachers to be there while students are working on problems to clear up misconceptions immediately instead of them having to struggle through the bulk of a work set not knowing what to do.]

[Interviewer: Is additional planning required to successfully implement a flipped classroom?]

[Participant: So planning and video time to actually make the videos.]

[Interviewer: So the planning time is then used mostly for video creation?]

[Participant: Are you talking about the planning period I have at school?]

[Interviewer: In general above and beyond what is normal for planning for a classroom.]

[Participant: Yeah, because it actually takes time to shoot and edit the video. Saving class time but you're losing planning time.]

[Interviewer: Have you completed any professional development towards flipped classrooms?]

[Participant: Not outside of my school, the whole school is flipped so we have in house stuff. And we have an in house tech guy.]

[Interviewer: Any particular PD that was found most helpful?]

[Participant: Umm, I don't think so, I don't remember any one particular session. I think that if someone wasn't comfortable with putting a video on their computer then they would need that kind of assistance, but I was already pretty comfortable with it.]

[Interviewer: Is there any that you would recommend for people going into a flipped classroom?]

[Participant: Be will to do one shoot done and not edit your video.]

[Interviewer: Does the use of online lectures increase level of student engagement or understanding?]

[Participant: I think it increases student engagement while they're in the classroom because they are not having to sit still and listen, they're getting to talk with each other. But

there's also kids that don't watch the videos or do the readings and that hurts them; it's harder to catch them up.]

[Interviewer: What is your opinion of the educational value of the flipped classroom?]

[Participant: Its good because it allows students to be able to re-listen to lectures anytime, whether they take advantage of that is a completely different story. And again, as a science teacher it frees up class time that can be used for more hands on investigative learning. Engage in the actually scientific process.]

[Interviewer: What was your opinion prior to flipping?]

[Participant: I always thought it was an interesting concept, and I only taught for two years in my own classroom before flipping. And it was in a low income area so flipping was not an option because there was no way to have devices for all of them. And I tried to do my own version of flipped classroom with the cart of laptops that we had and self-directed learning. It fell flat on its face, but that was because it was math and math teaching was not my game. But yeah, I always thought that it was an interesting concept and a good idea.]

[Interviewer: What do you think the benefits are?]

[Participant: I think that it allows you to be a lot more flexible with your class time, and I think it wins itself to more possibilities. So you can use it in a more traditional

classroom or going towards a more self-directed learning kind of outcome, where kids have all the lectures and can watch at a pace they want and go through the material at the pace they want.]

[Interviewer: What about drawbacks?]

[Participant: Drawbacks, the kids that do not watch videos fall behind and stay behind unless they take initiative to catch back up. There is not really a lot you can do, like if they are not motivated by their grades and their not motivated by learning, there's not much you can do. You can beat them about the head verbally as much as you like but there's not much you can do. The first year is a huge, huge tax on your time. I would say that's a major drawback especially for new teachers but I'm teaching a new subject and creating a flipped curriculum, but even teachers who have been teaching the same subject and went to the flipped curriculum, it just takes so much time to get your video library established.]

[Interviewer: Do you have all the resources you need to properly teach your flipped classroom?]

[Participant: Yes, I think so.]

[Interviewer: Is there anything you would find helpful to have?]

[Participant: If I wanted anything else, I would ask for it and it would happen our school, especially if it was for video making. I just usually use the webcam and Google Hangouts.]

[I: Keep it simple?]

[Participant: That's it.]

Appendix G: Participant A Textural Description

Participant A defined inverted classrooms as having the instructional materials being "presented in videos" which "students watch at home." "Traditional homework is presented in class" with "no content delivery during the class period."

Theme 1: Experience

Using the inverted classroom model, participant A has "much more time in the classroom" as "something that used to take... a class period to teach" could now be covered in a "10-12 minute video" where the students can be instructed to "stop the video and try this problem." Students have the ability to "go back and rewatch it" until it "makes so much more sense." This ability gives the impression to participant A that for the students, "it's like hearing the lecture twice."

Participant A reported being "very skeptical" of flipped classrooms prior to using them and "was worried about flipping because you miss the questioning that the students will do during lectures," but "you get that out of them the next day." Prior to flipping the classroom, participant A "didn't always know what [the students] were doing or how they were getting these wrong answers," but as a result, is now "sitting there while they are getting the wrong answers." It was also reported that participant A reported "learning so much about misconceptions", and could "clear them up immediately." The participant's classroom was "revolutionized" by the switch from traditional lecture-based teaching to a flipped model in part because "it just saves classroom time." While difficult to compare student achievement due to being in a different school when participant A flipped the

classroom, participant A “had the students perform very well on their end of grade test,” and “completed all the content and with time to review” “which [participant A] had never done before.”

While participant A stated it was not known “about the engagement during the video process because [participant A] [is] not there,” it was clear that “in class, it’s nothing but engagement.” Participant A is able to say to the students suspected of not watching the videos at home “‘Oh you know you didn’t watch you video? Well, you need to watch your video…, go watch it now’” “so it’s kind of a way to keep them accountable.” Participant A is “really able to tell if they understood the content or not” and “if they are answering [with] wrong answers,” they are able to “address misconceptions.” “It starts making [the students] ask questions” and is “very interactive.”

All of the videos are made by the teacher and while the first year was “very tough” Participant A is now “reaping those benefits this year” and is “able to make other videos this year that [participant A] wanted to make but couldn’t make.” The use of these videos allows participant A to cover more material than when teaching in a traditional format. “It frees up that really valuable class time to do things that [participant A] think[s] makes them understand the material better.” Prior to flipping, participant A “would never have the luxury of two days to let the kids make solutions.” Participant A reported that having that extra time was “priceless.”

While perceived as a potential negative, participant A iterated that the students “never struggle.” “The minute the students start to struggle there might be someone at their table that

can help them immediately," and there is a sense that "they are not problem solving for themselves as much as they used to," "they're not going to sit there alone struggling anyway."

Flipping the classroom "did not come naturally" to participant A, but believes "it's just a more efficient use of time" and that "content is delivered and the kids don't complain." Participant A reported while reflecting on the format, "'It's crazy that I took this job, but I love it.'"

Theme 2: Vicarious Experience

While Participant A creates all of the lecture videos for class, the participant will use a video "that has great animations and is correct" instead of the teacher-made video, but uses them for "more of a visualization." Students "are not picking up as much information from" non-teacher-made videos and are just "being entertained." Students have also reported that "they re-watch videos before tests, so it's almost like hearing the lecture twice or going to class twice." Student will "re-watch videos to relearn the content" and can do so at their convenience.

Participant A acknowledges a skill deficiency with respect to creating effects and more advanced video production and "cannot do the video editing that other people can do." Participant A finds that the "younger teachers… videos are amazing," and the biology teacher's videos are "awesome" and "the content she delivers is awesome." Participant A stated "'I can't make it fancy or have these great animations and things happening.'" With so many people coming "into this job already knowing how to do this stuff," participant A

believes that other, potentially younger, teachers have a greater technological knowledge base when creating videos.

Theme 3: Social Persuasion

Participant A "had to learn" how to effectively flip a classroom. Participant A had tried to flip a some lessons "for students going on a mission trip," in a different school, "but the administration said no." The participant "didn't know how to do any of this" (referring to the flipped classroom) before becoming employed by the high school being used in this study.

Participant A believes greater "knowledge" will help achieve better pedagogy surrounding the flipped classroom and needs "to learn how to do video editing." Much of the learning has been informal and the participant "just learned from the teachers" at the school. Participant A has also completed some online training and attended workshops and lectures, learning by "watching other people talk about flipping." Participant A was able to learn "what worked for them" and "what didn't work for them."

Participant A believes that flipping is content dependent and it "May not help… to watch an English flipped video because they're not solving problems." Participant A stated "'I think in the sciences, watch a science teacher."

Theme 4: Physiological Factors

For Participant A "that first year was tough." In the first year "there is a lot" and "it's very time consuming." "Just making the videos were time consuming" and the participant had difficulty finding time for all of the requirements needs for a successful classroom flip.

Participant A shared that “there were days when [the participant was getting up at 4am to make the video” for the day. Being the first year, the participant “didn’t have a library of videos to go to” in order to spend more time improving instruction.

Appendix H: Participant B Textural Description

Participant B defined inverted classrooms as "where the majority of direct instruction occurs outside the classroom usually via video," freeing up class time to "have more direct interaction," and "working on problem sets or more engaging activities."

Theme 1: Experience

Using the inverted classroom model, participant B teaches calculus and pre-calculus. In pre-calculus, participant B "record[s] almost the entire lesson," whereas in calculus, "it's more of an introductory lesson in the flipped video and then the class becomes more of a dialogue." Participant B believes that that dialogue is important and allowed by the flipped format and stated "'I feel you can't teach calculus without that dialogue with the student which you can't do via video.'" Flipping the classroom "wastes less time" in part "because students come in with foundational skills [participant B] need[s] to take it to the next step."

While having at least an introductory lesson completed prior to students' arrival in class adds time for other activities, it does add to the time spent planning for class. Having a content library available for reuse in later years, "becomes a real time saver." Even if the standards or curriculum order changes, "a lot of the content remains consistent" and "generally, it's not going to be re-recording the entire course" if there are changes year-to-year.

Participant B discussed that "it… takes some design" on the part of the teacher to flip a classroom. Emphasis was placed on incentivizing student buy-in to the flipped format and that "the teacher needs to go in from the start, making this part of the requirements of the

class.” Part of this involves “in some way incenting students to partake in watching the videos” because “if you have a significant number of students that don’t watch the videos then a flipped classroom, is just a waste of everyone’s time.”

Participant B referred to the flipped classroom as “great.” “In the past [participant B] would ask questions in class and get blank stares and now… get[s] discussion,” the students now “have some background knowledge.” “With flipping, [participant B] can turn it around and deliver lecture materials to [the students].” This allows students to “watch it as many times as they want, … rewind it, [and] … find additional resources.” The students “have a greater opportunity to get the skills communicated” to them.

With respect to the flipped classroom, initially, participant B saw that there could be “some value in it.” Participant B believed the students “were mature and would actually cooperate and do the stuff” and “it kind of has worked that way.” Participant B has had a change in “opinion of where to use the technique.” It was found that in “the lower levels it wouldn’t be as effective because students just wouldn't watch the videos.” Participant B stated that the “Most important thing is getting the buy-in of the students.” “It has to be the core of the course, its what you do.” If there is not student buy-in and legitimate participation “it really affects the environment for everybody".

Flipping the classroom has allowed participant B to have “more direct interaction time with students.” Participant B spends “more time walking around the room,” “sitting with students,” “working problems,” and “going towards a deeper understanding.” It is clear

that reflecting on teacher practices and adapting the flipped format to groups of students is an important function of the flipped classroom teacher.

Theme 2: Vicarious Experience

When first hearing of flipped classrooms, participant B "didn't quite get it." Participant B described what was referred to as "the blank sheet of paper effect" where students would leave class and attempt the homework only to sit and stare and a blank piece of paper. Having the flipped lessons, when students are "in class they get to practice, and if they have the blank sheet of paper effect in class," "they have the whole class, their classmates... and the teacher there to get the task done." This mitigates time wasted at home.

It is important that expectations are established as part of the course. "Students need to know they need to watch the videos." If the teacher re-teaches a lesson because students did not watch the video at home, students learn that "they are going to just come in and get the lesson anyways." Incenting the students to watch the videos causes them to be "more vigilant to watch the videos."

Theme 3: Social Persuasion

Participant B has had "no formal training" in flipping classrooms but believes that "somebody new to it" should have training, "there are a lot of options… and a lot of ways to do it." Participant B will discuss the flipped classroom with colleagues "at school during professional development." Participant B has all the needed resources at this time and "there is nothing [the participant] [is] hoping to get in the future right now."

Theme 4: Physiological Factors

Participant B stated that “there is additional outside of class time involved.” Participant B spends “a lot of time recording videos.” Due to it being the participant’s first year in the school being studied, “this year has been a rough year.” The participant is “recording the entire pre-calculus course” that the participant has “never taught” and “it’s time consuming”

The interview was conducted while the participant was on spring break. The participant stated, ‘“I have my pre-calc book in front of me and I’m planning recording a bunch of videos today,’” describing the amount of outside-of-class time was required. When it came to discussing the creation of the videos, the participant stated that “the time to record the videos is significant and additional.”

Appendix I: Participant C Textural Description

Participant C defined inverted classrooms as content delivery or lecture "is delivered at home" and "class time is spent with students actively participating with the information."

Theme 1: Experience

Using the inverted classroom model, participant C "always thought it was an interesting concept." Although the participant's first attempt at flipping a classroom "fell flat on its face," participant C believes "it is great for science because it gives [teachers and students] the whole class period for labs," and that "it increases student engagement." A part of the reason for initial failure was that the participant taught "in a low income area so flipping was not an option because there was no way to have devices for all of them," and the participant was teaching math which was "'was not my game.'"

Having students watch the lecture videos at home allows the participant "to be a lot more flexible with ... class time." Students can "watch at a pace they want and go through the material at the pace they want." Class time is freed up to "be used for more hands on investigative learning." Flipping the classroom also allows for more time "as teachers to be there while students are working," and can "clear up misconceptions immediately."

Theme 2: Vicarious Experience

Student buy-in and participation are key factors for success in a flipped classroom. The students who are actively participating "are not having to sit still and listen" and are "getting to talk with each other," Flipping allows all students "to be able to re-listen to lectures anytime."

However, some students do not “watch the videos or do the readings and that hurts them,” “it’s harder to catch them up.” These students tend to “fall behind and stay behind.”

Theme 3: Social Persuasion

Participant C has not attended and professional development “outside of [the participant’s] school”. The school has “in-house” training. Participant C does not have specific recommendations for training and the participant does not “remember any one particular session” personally attended as being more helpful than others. The participant “was already pretty comfortable with it.” Participant C was not lacking any needed resources and stated that if any resources were needed, ‘“I would ask for it and it would happen our school.’”

Theme 4: Physiological Factors

Participant C stated that “the first year is a huge, huge tax on your time.” Much of this time is used planning and finding “time to actually make the videos.” More time is spent on video editing. While teachers save “class time, but you’re losing planning time.” Participant C believes this to be a “major drawback, especially for new teachers,” who may need that planning time. Participant C stated, “it just takes so much time to get your video library established.

Appendix J: Composite Textural Description

Participants in this study held similar working definitions of inverted classrooms. Video recorded lectures were given to the students for viewing outside of the classroom. Class time was then used for hands-on activities, labs, working out problems, and/or working toward deeper understanding.

Theme 1: Experience

Previous experience. Teachers come into the school with varying levels of experience with inverted classrooms. These experiences range from none to experimental attempts to failure. Differing experience, or lack of, leads to feelings of skepticism and/or feelings of insecurity regarding inverted instruction.

Time. Classroom inversion allows more time in class for the teacher to facilitate learning. Students arrive in class and are able to participate in more investigative and hands-on learning. Time is also freed up for the students to engage in greater dialogue and discourse with the teacher as well as other students.

The time gained is a double-edged sword, however. In the first year there is considerable time required to create the content for the students to watch outside of class. This time is recouped in subsequent years provided the same subject is taught. The teacher can then reuse the videos and create new ones or re-record previous ones to edit content or provide more information.

Students are also free to spend as much time as needed to review the videos, pause, and take notes at their own pace. They are also able to watch the videos again prior to taking

a test to refresh their knowledge. Students absent from a class are able to watch the lecture at home and not miss all content covered on a particular day.

Teachers are able to use the time saved to cover more content and promote a deeper understanding of course topics. Less time is wasted giving the lecture, managing behavior, and repeating content.

Misconceptions. Teachers have a better understanding of the misconceptions students hold regarding material. This is a result of the additional time the teachers have to work through problems with students and watch the processes the students go through. Teachers are able to sit with the students as they incorrectly answer questions and address the reasons in real-time, rather than only seeing the end-results of the students' work and trying to determine the reasons post-hoc.

Design. It is important that teachers using inverted classrooms design their course with inversion in mind. Students must watch the video lectures at home for the classroom inversion to be successful. Teachers should be cognizant of the appropriateness of the courses/students for which he or she wishes to invert the curriculum. The teacher should consider available resources, course goals and needs, and school support. Classroom inversion (if used) should be a theme from the start of the course and expectations communicated to the students. Methods of student accountability for watching the videos are an important factor of success. Students that do not watch the videos tend to fall and stay behind, so incenting the students to participate is an important design consideration for inverted classrooms.

Theme 2: Vicarious Experience

Students who are active participants in inverted classrooms have more opportunities to work with and talk to other students rather than sitting and listening as a passive listener. Students are also able to rewatch videos if needed. In class, students can get assistance from teachers and students when faced with a task that presents a challenge or a struggle. It is important that students feel incented to watch the videos at home so they come to class prepared and for the teacher to hold them accountable.

There are some perceived deficiencies by the teachers as to their own technological skills when creating videos. Some videos created by younger, more technologically literate, teachers have higher levels of editing and effects. Videos created by less experienced teachers with respect to video editing are still effective. Having teacher-made, rather than found videos, is an important component for the students.

Theme 3: Social Persuasion

The majority of professional development for the teachers is in-house and informal. Teachers have to learn how to invert a classroom often as they are teaching in that format for the first time. With no formal training, teachers often rely on each other for help and guidance when inverting courses. Teachers are able to learn from each other and while teachers may desire additional training into pedagogy and technical skills, teachers feel comfortable discussing their methods with other teachers.

The school administrators are supportive and ensure resources are available for successful classroom inversion. This includes equipment, training, and software. The is an atmosphere of support among teachers and administrators surrounding inverted classrooms.

Theme 4: Physiological Factors

Time is a consistent factor in courses with inverted instruction. It is reported that teachers gain more time in class by having the lecture component completed at home. Creating those videos, however, creates a tax on the teacher's time. The first year requires the greatest additional time outside of normal classroom planning as the teacher must create the videos used for class. This time is primarily before and after school and over instructional breaks. In subsequent years, teachers have a library of videos to use which lessens the planning time needed.

Appendix K: Structural Description

The participants interviewed for this study are teachers in a public charter high school in a suburban area of North Carolina. The school has a stated focus on science, technology, engineering, and math competencies. The school opened for the 2012-13 school year with an inaugural freshman cohort of 145 students and has a current enrollment level of 341 students serving grades 9-11. The average classroom has 24 students. Student ethnic demographics are as follows: 8% Asian, 6% Hispanic, 6% other/multi-racial, 26% Black, 54% White. Twenty-two percent of students currently qualify for the federal free/or reduced lunch program.

The school has a focus on inverted classrooms and requires the format be taught by all its teachers. An demonstration of an inverted lesson is required for consideration of hire for employment with the school. All applicants are required to submit a <10 minute teacher-made video with follow-up activity. The applicant "teaches" this lesson as part of the interview process. The "flipped" classroom is a core concept of the school's educational model and the value placed on it is demonstrable in the school's hiring practices and relevant website content.

The school has placed an emphasis on making sure teachers have all needed resources available to the to ensure satisfactory classroom inversion practices. This includes technological resources (hardware and software), professional development, and in-house technical staff. The school follows a bring-your-own-device (BYOD) model for student computer technology use. Students without their own devices may use loaner computers

provided by the school. Students with no or limited Internet access are also provided time before, during, and after school to use the internet.

The school promotes and environment of collaboration among its faculty and the community at-large. Educators and researchers are welcome to schedule a tour that includes student and teacher interviews and conduct research on the methods used within the school. The school's website provides lesson plans, professional development videos, and information pertinent to the educational methods and philosophies of the school. These resources are available publicly with no log on.

Appendix L: Composite Description

All three participants in this study held similar working definitions of inverted classrooms. Video recorded lectures were given to the students for viewing outside of the classroom. Class time was then used for hands-on activities, labs, working out problems, and/or working toward deeper understanding.

Theme 1: Experience

Teachers are required to invert instruction and come to the school with varying levels of experience. While teachers may begin with some skepticism or prior failure with respect to classroom inversion, the school environment provides the resources necessary for successful implementation. Classroom inversion is a major focus of the school and required of all its teachers and a requirement of employment is a demonstrable inverted lesson. As such, resources are made available to teachers and an environment of collaboration is fostered within the school.

With classroom inversion, more class time is available for the students to work through projects and tasks and the teacher is more available for direct student interaction and assistance. This allows for teachers to create a deeper understanding of the topics and concepts in the students.

While greater time outside of class must be devoted to video creation and editing, teachers reap the rewards from that time spent in the first year of teaching a course in having a ready-made library for subsequent years. Students are also able to watch the videos, pause, and take notes at their own pace. They are also able to review the lectures prior to taking a

test and those absent from class are able to watch the lecture at home. More time is available for teachers to delve deeper into material and as a result, can cover more topics with time to review prior to final exams.

Less class time is wasted giving the lecture, managing behavior, and repeating content for students struggling with concepts. Teachers also have a better understanding of the misconceptions held by students that may have gone unnoticed in a traditional class format. Teachers are able to sit with the students as they incorrectly answer questions and address student conceptual issues in real-time, rather trying to determine the cause of the misconceptions post-hoc.

Teachers using inverted classrooms should design their course with that inversion in mind. Students must watch the video lectures at home for the classroom inversion to be successful. Teachers should be cognizant of the appropriateness of the courses/students for which he or she wishes to invert the curriculum. The teacher should consider available resources, course goals and needs, and school support. Methods of student accountability for watching the videos are an important factor of success. Students that do not watch the videos tend to fall and stay behind, so incenting the students to participate is an important design consideration for inverted classrooms. The school provides support in this area by creating a culture where inversion is not just expected of the teachers, but of students (and parents) as well. Students without the necessary resources (accessibility, time, hardware) are provided those opportunities through loaner computers and time before, during, and after school.

Theme 2: Vicarious Experience

Students who are active participants in inverted classrooms have greater opportunities to work with and talk to other students rather than sitting and listening as a passive listener. Students are also able to rewatch videos if needed. In class, students can get assistance from teachers and students when faced with a task that presents a challenge or a struggle. It is important that students feel incented to watch the videos at home so they come to class prepared and for the teacher to hold them accountable. Accountability is emphasized because if students fall behind by not watching the videos, there have a difficult time catching up. School structures and resources are made available to give students every opportunity to meet the requirements and address the challenges of an inverted classroom.

Some teachers perceive deficiencies in their own technological skills when creating videos. Videos created by younger, more technologically literate, teachers have higher levels of editing and effects. Videos created by less experienced teachers with respect to video editing are still effective. Having teacher-made, rather than found videos, is an important component for the students and this concept is supported and promoted by administration. Given the common construct of inverted classrooms throughout the school, collaboration between teachers helps teachers gain knowledge and confidence in their own pedagogy.

Theme 3: Social Persuasion

Professional development is a key component of successful classroom inversion. This is provided by the school with regular professional development meetings and as needed/requested by teachers. Formal training is either limited or non-existent with teachers relying on peer-to-peer guidance and informal discussions of experience with classroom inversion.

Teachers are able to learn from each other and while teachers may desire additional training into pedagogy and technical skills, teachers feel comfortable discussing their methods with other teachers. School administrators are supportive and ensure resources are available for successful classroom inversion. This includes equipment, training, and software. The is an atmosphere of support among teachers and administrators surrounding inverted classrooms.

Theme 4: Physiological Factors

Time is a consistent factor in courses with inverted instruction. Teachers gain more time in class by having the lecture component completed at home. However, video creation and editing is an additional tax on the teacher's time outside of class. The first year requires the greatest additional time outside of normal classroom planning as the teacher must create the videos used for class. The additional time is a stressor on inverted classroom teachers, especially in their first year(s) of teaching in an inverted classroom format.

Appendix M: Participant A Codes

Reference 1

the instructional material is presented in videos

Reference 2

the students watch at home

Reference 3

the traditional homework, is completed in class

Reference 4

there's no content delivery during the class period

Reference 5

None at all

Reference 6

I also have a way to tell if they watched it

Reference 7

they'll go back and rewatch it and it makes so much more sense

Reference 8

it's like hearing the lecture twice

Reference 9

The word revolutionized is probably the best word for it

Reference 10

much more time in the classroom

Reference 11

something that used to take me a class period to teach

Reference 12

I can make a 10-12 minute video

Reference 13

There are a lot of times in the video where I tell them to stop the video and try this problem

Reference 14

it just saves classroom time

Reference 15

before I didn't always know what they were doing or how they were getting these wrong answers

Reference 16

Now I'm sitting there while they are getting the wrong answers

Reference 17

I am learning so much about misconceptions about, and I can clear them up immediately

Reference 18

I do

Reference 19

our principal believes that there is some information they learn better from you as an instructor

Reference 20

I am not great

Reference 21

I cannot do the video editing that other people can do

Reference 22

I can't make it fancy or have these great animations and things happening

Reference 23

If there is a video out there that has great animations and is correct I'll use that instead of my video

Reference 24

I find they are not picking up as much information from that, they're being entertained

Reference 25

I guess I am using those videos for more of a visualization

Reference 26

So I make all my own videos

Reference 27

My first year

Reference 28

last year there were days when I was getting up at 4:00 to make the video, because I didn't have a library of videos to go to

Reference 29

Just making the videos were time consuming

Reference 30

the first year there is a lot

Reference 31

its very time consuming

Reference 32

I am reaping those benefits this year

Reference 33

I am able to make other videos this year that I wanted to make but couldn't make

Reference 34

it's a lot.

Reference 35

That first year was tough though

Reference 36

It was tough.

Reference 37

I have

Reference 38

I had a class from that gentleman from NC State who is big on the whiteboard flipping

Reference 39

He thinks that using the whiteboards are the most effective way for flipping

Reference 40

I went to one of his classes

Reference 41

I've done some online stuff

Reference 42

then I just learned from the teachers here

Reference 43

I had teachers here who had done it for a whole year who could help me

Reference 44

The workshops

Reference 45

Watching other people talk about flipping

Reference 46

what worked for them

Reference 47

what didn't work for them

Reference 48

t is kind of content specific as well

Reference 49

I think there is no better way to learn how to do it than to learn from someone that already has doing it in your content area

Reference 50

May not help me or another science teacher to watch an English flipped video because they're not solving problems

Reference 51

I think in the sciences, watch a science teacher

Reference 52

I think so

Reference 53

it’s not a really good scientific measure

Reference 54

I taught at a private school before, this is a public charter

Reference 55

it’s hard to compare when I wasn’t flipping and when I was

Reference 56

I had the students perform very well on their end of grade test

Reference 57

I completed all the content and with time to review

Reference 58

which I had never done before

Reference 59

I don’t know about the engagement during the video process because I am not there

Reference 60

in class it’s nothing but engagement

Reference 61

I rarely sit

Reference 62

I’ll say, “Oh you know you didn’t watch you video? Well, you need to watch your video, you know, go watch it now

Reference 63

So it’s kind of a way to keep them accountable

Reference 64

it’s very interactive

Reference 65

I'm really able to tell if they understood the content or not

Reference 66

If they are answering wrong answers we address misconceptions

Reference 67

it starts making them ask questions

Reference 68

I was worried about flipping because you miss the questioning that the students will do during lectures but you get that out of them the next day.

Reference 69

it was awesome!

Reference 70

would never have the luxury of 2 days to let the kids make solutions

Reference 71

Priceless

Reference 72

I was very skeptical

Reference 73

Very skeptical

Reference 74

I was so tired of not finishing content

Reference 75

students are out they miss the content

Reference 76

now they don't miss the content.

Reference 77

it's incredible

Reference 78

Skeptical

Reference 79

They never struggle

Reference 80

the minute the students start to struggle there might be someone at their table that can help them immediately

Reference 81

they’re not going to sit there alone struggling anyway

Reference 82

I do sense that they are not problem solving for themselves as much as they used to

Reference 83

I am able to back off on that a little bit

Reference 84

Students tell me that they re-watch videos before tests so it’s almost like hearing the lecture twice or going to class twice

Reference 85

they’ll re-watch videos to relearn the content

Reference 86

It frees up that really valuable class time to do things that I think makes them understand the material better.

Reference 87

it was fun

Reference 88

I think it’s just a more efficient use of time

Reference 89

I do

Reference 90

I had to learn

Reference 91

this did not come naturally to me

Reference 92

our younger teachers, their videos are amazing, the video editing

Reference 93

The biology teacher, her videos are just… they're awesome

Reference 94

She is very engaging in her videos

Reference 95

the content she delivers is awesome

Reference 96

I just didn't have time for all that stuff either

Reference 97

But my content is delivered and the kids don't complain

Reference 98

Knowledge

Reference 99

I need to learn how to do video editing

Reference 100

So many people come into this job already knowing how to do this stuff, I just did not

Reference 101

I actually wanted to flip some lessons for students going on a mission trip but the administration said no

Reference 102

They thought student engagement was really important

Reference 103

I didn’t know how to do any of this before I came

Reference 104

It’s crazy that I took this job, but I love it

Appendix M: Participant B Codes

Reference 1

he majority of direct instruction occurs outside the classroom usually via video

Reference 2

frees up time in the classroom to have more direct interaction

Reference 3

working on problem sets or more engaging activities

Reference 4

I will try to expand on what I have gone over in the video lesson in class rather than just reiterate it

Reference 5

In Pre-calculus I kind of record almost the entire lesson

Reference 6

In calculus it's more of an introductory lesson in the flipped video and then the class becomes more of a dialogue

Reference 7

I feel you can't teach calculus without that dialogue with the student which you can't do via video

Reference 8

there is additional outside of class time involved

Reference 9

The time to record the videos is significant and additional

Reference 10

The payback on it is in future years if I'm teaching the same course

Reference 11

reusing the same videos and then it becomes a real time saver

Reference 12

The standards will change but the a lot of the content remains consistent

Reference 13

So generally. It's not going to be re-recording the entire course.

Reference 14

I have not

Reference 15

nothing formal.

Reference 16

we'll have chats and talks at school during PD

Reference 17

no formal training

Reference 18

For somebody new to it yes

Reference 19

here are a lot of options on the technology and a lot of ways to do it

Reference 20

have been doing it for 3 years now I think and it started as an experiment

Reference 21

the teacher needs to go in from the start, making this part of the requirements of the class

Reference 22

in some way incenting students to partake in watching the videos

Reference 23

if you have a significant number of students that don't watch the videos then a flipped classroom, is just a waste of everyone's time

Reference 24

it just takes some design

Reference 25

I have heard different ways that people do it,

Reference 26

students need to know they need to watch the videos

Reference 27

Yes, because students come in with foundational skills I need to take it to the next step

Reference 28

it's great

Reference 29

In the past I'd ask questions in class and get blank stares and now I get discussion

Reference 30

they have some background knowledge

Reference 31

with flipping, I can turn it around and deliver lecture materials to them, they can watch it as many times as they want, they can rewind it, they can find additional resources or I post additional resources

Reference 32

they should have a greater opportunity to get the skills communicated

Reference 33

when they're in class they get to practice, and if they have the blank sheet of paper effect in class then guess what, they have the whole class, their classmates are there and the teacher there to get the task done

Reference 34

it wastes less time

Reference 35

When I first heard about it I didn't quite get it

Reference 36

hen when I saw okay there could be some value in it

Reference 37

The reason I did it was I thinking they were mature and would actually cooperate and do the stuff and it kind of has worked that way

Reference 38

The change in my opinion is that at the lower levels it wouldn’t be as effective because students just wouldn't watch the videos

Reference 39

I think that is what makes students that watch the videos more vigilant to watch the videos because they are going to just come in and get the lesson anyways

Reference 40

I have changed my opinion of where to use the technique

Reference 41

more direct interaction time with students

Reference 42

I am spending more time walking around the room

Reference 43

sitting with students and working problems

Reference 44

going towards a deeper understanding

Reference 45

I’m spending a lot of time recording videos

Reference 46

This year has been a rough year,

Reference 47

I started at a new school where everything is flipped, so I’m recording the entire pre-calculus course which I have never taught

Reference 48

its time consuming

Reference 49

I’m actually sitting here on my spring break, I have my pre-calc book in front of me and I’m planning recording a bunch of videos today

Reference 50

I have all the resources I think I need to do what I do.

Reference 51

There is nothing I am hoping to get in the future right now

Reference 52

Most importing thing is getting the buy in of the students

Reference 53

It has to be the core of the course, its what you do

Reference 54

that has to be done otherwise it really affects the environment for everybody

Appendix O: Participant C Codes

Reference 1

Where the content delivery or like the lecture part of the class is delivered at home

Reference 2

class time is spent with students are actively participating with the information

Reference 3

I think it is great for science because it gives us the whole class period for labs

Reference 4

it also allows time as teachers to be there while students are working

Reference 5

to clear up misconceptions immediately

Reference 6

So planning and video time to actually make the videos

Reference 7

because it actually takes time to shoot and edit the video

Reference 8

Saving class time but you're losing planning time

Reference 9

Not outside of my school

Reference 10

we have in house stuff

Reference 11

I don't think so

Reference 12

I don't remember any one particular session

Reference 13

I was already pretty comfortable with it

Reference 14

Be willing to do one shoot and done and not edit your video

Reference 15

I think it increases student engagement

Reference 16

they are not having to sit still and listen

Reference 17

they're getting to talk with each other

Reference 18

ut there's also kids that don't watch the videos or do the readings and that hurts them; it's harder to catch them up

Reference 19

Its good

Reference 20

it allows students to be able to re-listen to lectures anytime

Reference 21

it frees up class time that can be used for more hands on investigative learning.

Reference 22

I always thought it was an interesting concept,

Reference 23

it was in a low income area so flipping was not an option because there was no way to have devices for all of them

Reference 24

I tried to do my own version of flipped classroom with the cart of laptops that we had and self-directed learning

Reference 25

It fell flat on its face,

Reference 26

that was because it was math and math teaching was not my game

Reference 27

it allows you to be a lot more flexible with your class time,

Reference 28

can watch at a pace they want and go through the material at the pace they want.

Reference 29

the kids that do not watch videos fall behind and stay behind

Reference 30

The first year is a huge, huge tax on your time.

Reference 31

that’s a major drawback especially for new teachers

Reference 32

even teachers who have been teaching the same subject and went to the flipped curriculum

Reference 33

it just takes so much time to get your video library established

Reference 34

Yes, I think so.

Reference 35

I wanted anything else, I would ask for it and it would happen our school,

Appendix P: Researcher's Personal Description

I have been a classroom for four years with classroom experience teaching science, technology, engineering, and math content in both middle and high school. I have taught traditional lecture-based and project-based courses with high levels of technology integration. I have always encouraged fellow teachers to integrate technology into their classes and regularly lecture about best practices.

I have attempted to flip a few classrooms with little success. I attributed that lack of success to a lack of access for students at home (or at least a lack of effort), the added time requirements to implement it, and difficulty moving forward if the students did not watch the videos at home.

I have done extensive research on flipped classrooms and attended a large number of conference presentations and trainings on how to flip a classroom. I have been biased against their general use in classrooms. While I have seen successful classroom flips, I have not seen the added value of then personally and the research does not show significant gains in student outcomes. The may have value, but I don't personally see that it is yet worth the resources being spent on it, nor an increase in student outcomes that justifies their use as an experimental practice.