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Effects of an Inverted Instructional Delivery Model on Achievement of Ninth-Grade Physical Science Honors Students

Donna Howell
Gardner-Webb University

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By
Donna Howell

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Sydney Brown, Ph.D. Committee Chair	Date
Wendy Edney, Ed.D. Committee Member	Date
Ramsey Musallam, Ed.D. Committee Member	Date
Jeffrey Rogers, Ph.D. Dean of the Gayle Bolt Price School of Graduate Studies	Date

Abstract

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This mixed-methods action research study was designed to assess the achievement of ninth-grade Physical Science Honors students by analysis of pre and posttest data. In addition, perceptual data from students, parents, and the researcher were collected to form a complete picture of the flipped lecture format versus the traditional lecture format.

The researcher utilized a 4MAT learning cycle in two Physical Science Honors classes. One of these classes was traditionally delivered with lecture-type activities taking place inside the classroom and homework-type activities taking place at home; the other inverted, or flipped, delivered with lecture-type activities taking place outside the classroom and homework-type activities taking place inside the classroom. Existing unit pre and posttests for both classes were analyzed for differences in academic achievement. At the completion of the units, the flipped class students and parents were surveyed, and student focus groups were convened to ascertain their perceptions of the flipped classroom delivery model.

Statistical analysis of posttest data revealed that there is no significant difference between the traditional lecture delivery format and the flipped delivery format. Analysis of perceptual data revealed six themes that must be considered when deciding to flip the classroom: how to hold students accountable for viewing the at-home videos, accessibility of students to the required technology, technical considerations relating to the video production, comprehension of the material both during and after viewing the videos, pedagogy of the overall flipped method, and preference for the flipped method overall.

Findings revealed that students, parents, and the researcher all had a preference for the flipped class format, provided the above issues are addressed. The flipped class format encourages students to become more responsible for their learning, and, in addition, students reported that the hands-on inquiry activities done in class aided them in learning the subject matter. It is recommended, however, that before instructors decide to flip the classroom, they ensure that all students have access to needed technology, that there is a plan in place for ensuring that the students actually view the assigned videos, that they have a way to create the videos and ensure adequate quality, and that some discussion is held in class after each assigned video to ensure comprehension of the material.

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Chapter 1: Introduction

Introduction and Nature of the Problem

In a 21st Century global marketplace, a highly qualified workforce is needed for the U.S. to be competitive, with future employees skilled in math and science; however, producing graduates skilled in the areas of math and science seems to be the greatest failure of the U.S. educational system (*Rising above*, 2010).

Price (2011), a writer for *Congressional Quarterly* magazine and author of numerous public policy articles in the field of science, stated that China awarded university degrees to 800,700 students, as compared to the 242,000 awarded in the U.S.; and that the U.S. is losing its major share of the world's science patents to China and other Asian countries as they try to lift themselves out of the depths of poverty. Indeed, Price quoted Lockheed Martin's Norman Augustine, who was chairman and CEO from 1995 until 1997, as saying, "science thrives where people can challenge the status quo, where they don't just routinely accept boundaries, where they can innovate and create" (p. 64). Today's scientific landscape has radically changed. Ferris-Berg (2008) stated that

> Today's leading technological thinkers assert that our nation's people must achieve basic STEM (science, technology, engineering and math) literacy if we expect to solve the greatest challenges of the 21st Century. While some of today's students will be producers of scientific knowledge, it's likely that the majority will be knowledge consumers. As democratic decision-makers, all consumers will have an important role in the advancement of science, which will include taking-up new technologies, funding research, and critically assessing the validity of new assertions. Solving 21st Century problems will be a collective

> responsibility. (p. 1)

However, Ferris-Berg (2008) further went on to state that today's students merely see science as a means to an end–a high school diploma–and this may be due to how students are learning science. She also said that students still are being taught with traditional methods and are memorizing a great body of seemingly unrelated facts as opposed to learning what to do with those facts. Only 16% of teachers surveyed reported using methods that help students develop their problem-solving skills (Ferris-Berg).

> Too often science education fails to engage student interests and is separate from their everyday experiences. Curriculum and education reform efforts suggest that when students "do science" they gain knowledge and skills that are transferrable to future problems and that help prepare them to approach college and career with the tools to succeed. (Laboy-Rush, 2007, p. 3)

In 2001, the No Child Left Behind Act (NCLB) was authorized by the United States Government (United States Department of Education, 2010) to promote school reform; and in its purpose statement, two of the ways it said reform can be accomplished are by

> providing children an enriched and accelerated educational program, including the use of schoolwide programs or additional services that increase the amount and quality of instructional time; and promoting schoolwide reform and ensuring the access of children to effective, scientifically based instructional strategies and challenging academic content. (p. 15)

Price (2008) stated that because the standardized test scores mandated by NCLB are part of the Report Card for the school and, thus, part of a school's overall evaluation, schools have increasingly focused on those subjects that were being tested–mathematics and reading–and as a result, high schools are producing "graduates who aren't prepared to study college-level science, according to ACT, an education and workforce development organization best known for its college admission testing" (p. 31). In fact, Price cited ACT as saying that only 28% of high school graduates were actually ready for college science.

Hennessy (2002) claimed the reasons for the above problem are perhaps lack of rigor as compared to other countries, teachers trying to cover the whole textbook instead of just the standards, making the information covered very broad but lacking in depth, and teachers spending too much time teaching discrete pieces of information, but little time on using reasoning to have students come up with the information on their own. To rectify this problem, the emphasis should shift from 20th Century skills, which emphasize learning units of knowledge, to 21st Century skills, which instead emphasize learning what to do with the knowledge (Silva, 2008).

Muniandy, Mohammad, and Fong (2007) suggested that in order for school reform to be successful, there are three agendas that must converge: learning theory, pedagogy, and technology. Indeed, they also said that for comprehensive school reform to be successful, constructivism, project-based learning, and technology should not only be integrated on a concurrent basis, but should also form a synergistic relationship. Mishra and Koehler (2006) suggested that there is a complex interplay between technology, pedagogy, and content knowledge, and that educators must look at all three parts of the framework when designing instruction.

Teachers in the 21st Century are more likely to teach students whose learning styles and preferences are a product of the technology that is available to them on a daily basis (Coates, 2007). Coates (2007) also said that in order for educators to respond to the diversity of generations in the classroom, it is crucial that they examine generational learning styles so that they can create an educational experience that is appropriate for their generation of students. In particular, science pedagogy should encompass not only generationally based learning styles, but also the student-centered model of inquiry learning. Brown (2003) agreed that the traditional *one size fits all* science pedagogy is not meeting the needs of today's diverse student populations; we must move toward a student-centered learning model where the needs of each individual student are considered. Indeed, in 1996, the National Research Council (NRC) said that the modern science curriculum should be inquiry-based and student-centered (Bybee, 2010). Llewellyn (2005) suggested that a prerequisite for an inquiry-based curriculum is the philosophical underpinnings of the principles of constructivism, which is a learning theory based on the assumption that students construct meaning of the world around them by building upon existing knowledge.

With the advent of many new technologies for learning, today's student can learn with the aid of the technology they are used to, thus capitalizing on their unique learning styles. Strommen and Lincoln (1992) stated that the evolution of new technologies actually contributes to a student-centered learning environment. Lage, Platt, and Treglia (2000) said that the goals of using technology in the classroom are consistent with the goals of a teaching delivery model known as the inverted, or flipped, classroom model. The flipped classroom has been defined as one in which what is traditionally done in class, such as lecture, is now done at home; and what is done at home, such as homework, is now completed in class (Bergmann & Sams, 2012). "Flipping the classroom establishes a framework that ensures students receive a personalized education tailored to their individual needs" (Bergmann & Sams, 2012, p. 6).

Statement of the Problem

In the subject of science, the traditional methods of teaching have been in-class lecture, memorization of lots of small facts, and utilization of formulas (Alic, 2006). Since the 1983 report issued by the National Commission for Excellence in Education entitled *A Nation at Risk*, there has been much research on how to best teach science in standards-based reform (Gardner, 1983). However, this reform has resulted in little improvement in science achievement as measured by the Benchmarks for Science Literacy, and there continues to be a gap in achievement between majority and minority students (Alic, 2006). Indeed, Alic (2006) also stated that since the 1970s, traditional methods of teaching science have little to do with actual learning of science; rather, research suggests that students learn by doing science through teaching methods such as inquiry-based learning.

Many educators are beginning to use the *flipped classroom* teaching model as a way to incorporate 21st Century teaching methods into their classroom (Ash, 2012). However, many critics of the method believe that flipping is “simply a high-tech version of an antiquated instructional method: the lecture” (Ash, 2012, p. 6).

Collins and Halverson (2009) posed the question, “What might happen if our thinking about learning doesn’t change? If schools cannot change fast enough to keep pace with advances in learning technologies, learning will leave schooling behind” (p. 131). This was the problem that the rural high school in which this research took place seemed to be facing. Averaged over the last 5 years, this high school’s state Physical Science end-of-course (EOC) test scores were not only below the average of other schools of similar makeup in the state but also below the state average for all schools. The exact data are outlined in Table 1 (EOCEP, 2012; Report Cards, 2011).

Table 1

Comparison of Physical Science EOC Test Data for Years 2007-2011: Percent Pass Rates

Year	Rural High School	Similar Schools in State	State Average
2007	30.2	43.6	70.7
2008	52.6	49.2	72.2
2009	39.8	46.2	72.4
2010	41.8	50.0	73.8
2011	44.5	52.2	73.9
5 Year Average	41.8	48.2	72.6

Note. Similar schools are defined as high schools in the same state with poverty indices of no more than 5% above or below the index for this school.

Another problem noted is that for all other district high school science EOC tests, excluding the state EOC for Physical Science, pass rates in this high school are also traditionally very low: For the 2010 and 2011 school years, which are the only data available per the district office, the average test grade was 65.4% (Researched district's website, 2012).

Deficiencies in the Literature

There are a few identified deficiencies in the literature. Dimock and Boethel (1999) asserted that more research needs to be done on creating constructivist learning environments that are supported by technology. In the field of science, teachers are often quick to embrace technology; however, research on the technology trails behind its actual use (Bell, Schrum, & Thompson, 2008). "Consequently, apart from isolated studies, comparatively little understanding of the role of technology in the design of student-centered learning environments has evolved" (Hannafin & Land, 1997, p. 168). Research has found that "although some successful instances of technology implementation have been reported, overall the potential and promise for educational technology appears to have gone unfulfilled" (Bell et al., 2008, p. 1). Specifically, Sugar, Brown, and Luterbach (2010) agreed that research needs to be done on which type of instructional strategies utilizing technology most impact student achievement.

Purpose of the Study

The purpose of this quasi-experimental action research study was to, within the 4MAT inquiry-based learning cycle, compare the effects of two models of instructional delivery, the traditional delivery model and the inverted delivery model, on the achievement of ninth-grade Physical Science Honors students as measured by existing pre and posttests. Students' and parents' perceptions of the inverted method of instruction, along with the researcher's reflections on the process, were gathered and analyzed to determine overall perceptions of the inverted model.

I have chosen to use the 4MAT learning cycle model of instruction because it is a research-based model that is aligned with the National Science Teacher's Association's mandate for inquiry models of instruction. Although the 4MAT learning cycle has been shown to increase posttest scores at a statistically significant level over a traditionally taught class (Tatar & Dikici, 2009), the effects of inverting the second part of the 4MAT learning cycle has not been a subject of research.

Setting

The high school in this rural school district employs 107 teachers, 59.8% of whom hold degrees at the Master's level or above. The percent of classes taught by highly qualified teachers is 99%. The number of students totals 2,051. Of these, 21.6%

are eligible for gifted and talented services. The student-to-teacher ratio is 30.8 to 1 in core courses, compared to 26.5 to 1 in other affinity groups (Report Cards, 2011). Approximately 63% of students receive free or reduced-price lunches. The racial/ethnic makeup includes 64% Caucasian, 30.5% African American, 5.1% Hispanic, and 0.4% other races (*Active student headcounts*, 2012).

According to a school assistant administrator's observations in the 2011-2012 school year, classes in this school's science department are being taught using a traditional delivery format; that is, the teacher performs lecture in class to introduce a subject, worksheets are done at home and in class to reinforce the subject, and most laboratories are created by the teacher with research questions already provided and only one conclusion possible (A. M., personal communication, August 19, 2012).

Research Questions

The research questions to be answered in this study were:

1. Within the 4MAT model of inquiry-based instruction, what are the effects of an inverted instructional model of delivery on the performance of ninth-grade Physical Science Honors students as compared to traditionally delivered instruction?
2. What are students' perceptions of the inverted instructional model of delivery?
3. What are parents' perceptions of the inverted instructional model of delivery?
4. What are the instructor's perceptions of the inverted instructional model of delivery?

Role of the Researcher

I have been a member of the faculty at this high school for the past 11 years and am still an active faculty member in the science department. I have taught Physical Science Honors for all of the 11 years and am currently teaching two Physical Science

Honors classes for the 2012-2013 school year. I received my M.Ed. in Secondary Science Education in 2001 and became a National Board Certified teacher (AYA/ Science) in 2008. I received my M.A. in Executive Leadership Studies in 2012, and am currently working on my Ed.D. in Curriculum and Instruction. I routinely utilize differing forms of technology in my classroom, including the ActivBoard, Classroom Performance System (CPS), iPads, and cellphones, and frequently instruct students in the use of software applications such as Windows Movie Maker, Camtasia, Glogster, Educreations, Explain Everything, Toontastic, and other productivity software as pertinent to various classroom projects. As primary investigator in this action research study, I gathered data to assess the impact of an inverted instructional model of delivery on course performance and satisfaction within the 4MAT inquiry-based learning cycle model, and then used the findings to make recommendations for improving my own teaching and my site's science program with the goal being to ultimately positively impact district EOC test scores. Although the scope of this research was limited to only ninth-grade Physical Science Honors students and, therefore, not generalizable for all populations, I hope to provide recommendations to other teachers and schools interested in utilizing the flipped classroom model of delivery in their science classes.

Definitions of Major Concepts and Terms

The following are the definitions of terms that were used within the scope of this research and study.

4MAT learning cycle. A four-step cycle of learning "that begins with engaging the student and moving them toward reflective observation" (McCarthy & McCarthy, 2006, p. ix).

Action research. Any systematic inquiry conducted by teachers, administrators, counselors, or others with a vested interest in the teaching and learning process or environment for the purpose of gathering information about how their particular schools operate, how they teach, and how their students learn (Mertler, 2006, p. 2).

Constructivist theory. A philosophical approach to education where knowledge is constructed by students during their experiences (Dimock & Boethel, 1999).

Inverted (flipped) classroom. A classroom in which activities that traditionally have taken place inside the classroom, such as lecture, are switched with activities that have traditionally taken place outside the classroom, such as homework (Lage et al., 2000).

Learning cycle. An instructional strategy for teaching science whereby the concept is introduced, discussed, and applied through a series of constructivist activities (Abraham, 1997).

Perceptions. "The process by which people translate sensory impressions into a coherent and unified view of the world around them. Though necessarily based on incomplete and unverified (or unreliable) information, perception is equated with reality for most practical purposes and guides human behavior in general" (*Perception*, 2012, p. 1).

Scientific inquiry. Method whereby students learn how to ask questions and use evidence to answer them. In the process of learning the strategies of scientific inquiry, students learn to conduct an investigation and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions. (*NSTA position statement*, 2012, p. 1)

Screencasting. A way to present digitally recorded playback of computer screen output, which often contains audio narration, and to visually demonstrate procedural information to students (Sugar et al., 2010).

Student-centered classroom. A classroom where control for learning is assumed by the student (Brown, 2003).

Traditional model of delivery. A classroom in which instructional delivery takes place during the school day face-to-face via lecture, and homework takes place outside of the school day.

Summary

In order to transition our students into the 21st Century workplace, schools must discard the 20th Century teaching model. The use of technology can facilitate this shift. Utilization of technology better equips the classroom teacher to serve different student learning styles (Turkmen, 2006). Joy and Garcia (2000) suggested that teachers should be asking the question, "What combination of instructional strategies and delivery media will best produce the desired learning outcome for the intended audience?" (p. 38). Turkmen (2006) quoted many studies which showed students who used hands-on instruction together with technology had improved attitudes toward science and increased knowledge of the subject.

Bybee (2010) stated that early 21st Century teachers continue to face many challenges today that have been challenges in the past. Some of these are "achieving science literacy, reforming science programs, teaching science as inquiry, improving science teachers' knowledge of skills, and attaining higher levels of achievement for all students" (p. 1). The inverted, or flipped, classroom is an instructional model that enables students to utilize technology outside of the classroom to provide class content, while completing traditional homework-type activities inside the classroom. This study was designed to answer questions about whether or not the inverted classroom method of instructional delivery is better than the traditional face-to-face model of instructional delivery with regard to student perception and achievement.

In Chapter 2, a review of related literature is presented in the areas of generational learning styles, science pedagogy, the inverted classroom, and the action research method. Chapter 3 outlines the methodology used in the action research process. Chapter 4 presents detailed findings related to the action research project, and Chapter 5 provides an analysis of the research findings and makes recommendations for programs and further research.

Chapter 2: Literature Review

Introduction

More than a century ago, John Dewey (1916) said, "If we teach today as we taught yesterday we rob our children of tomorrow" (p. 167). Susan Brooks-Young (2010) elaborated and discussed how our current model of education is no longer appropriate because it is still a product of the Agrarian and Industrial Ages, reflecting educational needs of earlier centuries. Brooks-Young also said:

> Students who live in industrialized nations around the world are increasingly disenchanted with the education programs being provided. They view educators who use traditional teaching methods as being out of touch. They rankle at completing the same projects and assignments their parents and even grandparents did when they attended school. They believe that the technology tools that are banned on campus are, in fact, the keys to success in their future. (p. 1)

Marc Prensky (2010) discussed three areas of education that will affect students' futures. First, he stated that the students we teach are changing as a result of their lives outside of the classroom and, thus, require an education that is more in line with the real world in which they live. Second, he stated that the traditional form of pedagogy, lecture, is not as effective with our students today for this same reason. Third, he stated that digital technology is entering our classrooms at a rapid pace, and "can make our students' learning real, engaging, and useful for their future" (Prensky, p. xv). In its 2010 Horizon Report, the New Media Consortium (Johnson, Smith, Levine, & Haywood, 2010) identified one of the key challenges of education as the very structure of the K-12 education system. Indeed, Collins and Halverson (2009) stated, "There are deep incompatibilities between the demands of the new technologies and the traditional school" (p. 6). Looi et al. (2010) said that learning does not have to take place at fixed times and places anymore–that with new mobile technologies, students can learn inside and outside of the classroom at a time of their convenience.

The Economist Intelligence Unit conducted a survey on how technology is changing today's classrooms. According to this survey, one important use of technology to support classroom learning in the next few years will be the use of software that supports students' learning (*The Future of Higher Education*, 2008). One type of technology being utilized in this capacity is the screencast. A screencast is "a digitally recorded playback of computer screen output which often contains audio narration" (Sugar et al., 2010, p. 2). A screencast can be used to digitally record lecture-type material for students and can be used to provide an overview of a subject, describe a procedure, present a concept, focus attention to an issue, or elaborate content (Sugar et al., 2010).

This literature review presents current research in the areas of generational learning styles, learning theory, science pedagogy, and infusion of technology in science teaching, and demonstrates how all of these can be melded into a 21st Century inverted teaching model. In addition, the quasi-experimental action research methodology is explored.

Generational Learning Styles

In the past, schools have been very efficient at educating students in preparation for the industrial era; however, in the new era of information and technology, we need to totally rethink the way we teach (Coates, 2007). "As society evolves in response to the changes in demographics, technology, and political forces that contribute to the development of 21st Century culture, how we learn and what we need to learn will change as well" (Coates, 2007, p. 17).

Coates (2007) defined learning styles as "the manner in which an individual perceives and processes information in learning situations" (p. 9). Coates asserted that learning styles vary by generations and that parallels are apparent between changes in society's forces and how people learn. She further asserted that learning style indicators are tools that educators must utilize in the classroom to ensure the success of their students. Generations have been defined as "cohorts of people who were born in a certain date range and share a general cultural experience of the world" (Ivanova & Smrikarov, 2009, p. 1).

Generation X is defined as those people born roughly between 1965 and 1979, who were influenced by technologies such as cable television and video games (*Consumers*, 2011). Generation Y is defined as those people born roughly between 1980 and 1995, who were influenced by technologies such as e-mail, the Internet, and text messaging (*Consumers*, 2011). Generation Z, which includes students just entering the high school realm, is defined as those people born between approximately 1996 and 2010, who were influenced by technologies such as the Internet, smart phones, and social networking sites. They are the first real Internet generation. Also known as digital natives, this generation is technologically savvy, is connected to the world via technology, and is more tolerant of diverse cultures (*Consumers*, 2011). Research has shown that 43% of this generation prefers learning from the Internet, 38% prefer print and digital learning, and only 16% prefer books as their favorite way of learning (*Consumers*, 2011). Coates (2007) said that technology is an extension of the students themselves, and that since their classroom is the world, they can learn independently to a great extent. These children must constantly be stimulated by technology, and if they are not, they become uninterested in traditional education (Jones, Jo, & Martin, 2006).

Because of the unique experiences and needs of Generation Z students, a 21st Century pedagogy should be relevant, student-centered, collaborative, time-appropriate, visual, and with multiple levels of technology incorporated (Coates, 2007). Prensky (2010) stated that today's students do not want to be lectured to; they want to create using the technology tools they are used to, they want to work collaboratively with their peers, they want to share class control and participate in decision-making, and they want an authentic and relevant education. Prensky also suggested that for a true 21st Century classroom to be effective and meet the needs of Generation Z, teachers must employ strategies such as asking guiding questions but allow the students to research and find the information on their own, must create rigor, and must ensure quality of education. Quellmalz and Haertel (2000) maintained that technology is the medium to move teachers from 20th Century teaching methods to 21st Century teaching methods and will help to deepen students' knowledge and understandings of the material. Specifically, in the subject of science, this technology enables the teachers and students to use technology for monitoring, evaluation, reflection, presentation, communication, analysis, interpretation, investigation, and planning (Quellmalz & Haertel).

> The hypertext minds of 21st Century Learners crave interactivity, are good at reading visual images (though weak with reading skills), have strong visual-spatial skills, tend toward parallel processing and inductive discovery, and look for fast response times which leads to short attention spans. (Rodgers, Runyon, Starrett, & Von Holzen, 2006, p. 2)

In conclusion, Ivanova and Smrikarov (2009) summed this up by saying, "the adoption of Web 2.0 services and e-Learning 2.0 techniques is unavoidable if we aim at catching up Generation Y and Z students" (p. 8). Understanding the learning styles of today's students will not only affect how we teach, but also is important in ensuring that our students receive the type of education that best prepares them for the challenges of the 21st Century (Coates, 2007). Clearly a 21st Century pedagogy is needed to engage this type of learner.

Science Pedagogy

The 21st Century world we live in is changing at a rapid pace; however, most schools are still rooted in 20th Century pedagogy. As the Industrial Age created an educational system that was built for the demands of an industrial economy, the Informational Age and the Age of Technology today require an educational system that meets the needs of today's technology-centered society (Coates, 2007). Gradually, there has been a shift from traditional, teacher-centered instruction to a more student-centered model of instruction with its roots in the constructivist learning theory. What sets the traditional classroom apart from the 21st Century classroom is how and where the instruction is delivered (Brown, 2003). Lage et al. (2000) said that evidence points to a correlation between students' learning styles and the instructor's teaching style.

Teacher- vs. student-centered. The traditional educational system was created using the factory model of management, where the efficiency of the school system overall was paramount, and everyone from the top down had to adjust to the system (Denning, 2011). Denning (2011) also stated that there are some longstanding principles of a traditional educational system that are the underlying tenets: a bureaucracy responsible for creating the overall plan and the tests, the assumption that cutting costs was necessary to maintain efficiency, the idea of top-down instruction, and sage-on-the-stage teachers who produce outputs, or students who pass standardized tests. In a traditional setting, students are taught in a rote way as a whole class, with the emphasis being on the three R's: reading, writing, and arithmetic (Jones et al., 2006). In this traditional model, direct in-class instruction is the main way of imparting information, and teachers do not have time to utilize open-ended questions nor problem-based learning (Brown, 2003). As a result, this teacher-centered type of environment doesn't allow for the unique learning needs of individuals and thus perpetuates inequities among children (Brown, 2003).

Gradually, a paradigm shift occurred where learning began to be about the students and their frame of mind (Silva, Sabino, Adina, Lanuza, & Baluyot, 2011). "Since the turn of the century, the challenges of globalization, information technology, international competition, and strong local developments have stimulated a new wave of educational reforms" (Cheng & Mok, 2008, p. 374). The new wave has shifted from a teacher-centered paradigm to a student-centered one. Cheng and Mok (2008) described this new paradigm as one where learning should be tailored to meet the needs of the individual student; one where the focus of learning shifts to how to learn, create, think, and develop with the ultimate goal being lifelong learning. A student-centered environment is a constructivist one in which students construct their own personal meaning by taking what they learn and relating it to what they already understand (Hannafin & Land, 1997).

Additionally, this type of learning can take place inside or outside a class, globally or locally (Cheng & Mok, 2008). In her 2007 book entitled "Generational Learning Styles," Julie Coates stated that there are some basic characteristics of a learner-centered curriculum: It is collaborative, not competitive; it is relevant and time-appropriate; it is outcomes-based, customized, and interactive; and it incorporates technology, is visual, and provides clear expectations.

In 1997, the American Psychological Association (APA), in response to the student-centered paradigm shift, published their Learner-Centered Psychological Principles. They are summarized in Figure 1.

Influences on Learning	Actions of Successful Learners That May Be Promoted by Teachers
Cognitive and Metacognitive	1. Actively make meaning and self-regulate. 2. Seek personally-meaningful goals. 3. Link past, present, and future learning. 4. Think critically and creatively. 5. Direct, monitor, and improve their thinking. 6. Co-regulate learning with the environment.
Motivational and Affective	7. Use motivation to learn. 8. Stimulate internal goals and interests. 9. Exert effort to sustain and enhance motivation.
Developmental, Social, and Individual	10. Engage developmentally-appropriate tasks. 11. Interact and collaborate to learn. 12. Accept and adapt to their differences. 13. Take cultural backgrounds into account. 14. Have high goals and seek ongoing feedback.

Figure 1. Learner-Centered Psychological Principles.

Brown (2003) took it one step further, outlining 12 conditions that are a product of the APA Learner-Centered Psychological Principles: Guidelines for School Redesign and Reform. The 12 conditions are that classrooms must be student-centered, not content-centered; teachers must believe that all students can learn; classrooms must be success-oriented; learning must be active; instruction must be developmentally appropriate; instruction must address diverse learning styles; students must work together; teachers must be facilitators of learning; students must have choices; learning must be contextually relevant; many forms of assessment must be used; and teachers must be reflective practitioners.

> It has been apparent since at least the late 1970's that traditional methods of teaching science–lectures, textbooks, memorization of facts, theorems, and formulas–have little to do with learning science. Rather, a large body of research has clearly demonstrated that children learn science by doing science–a process called inquiry-based learning, a form of constructivist instruction. (Alic, 2006, p. 2)

The roots of the inquiry method of teaching science can be traced back to John Dewey, who proposed that scientific knowledge is constructed through the process of inquiry. In 1996, the NRC released recommendations for science students in the United States that would enable them to be more competitive with other countries, identifying inquiry as the principal method of teaching science (Llewellyn, 2005). In response, in 1998, the National Science Teachers Association (NSTA) adopted a position statement that said teachers should promote inquiry-based instruction, providing class experiences that enable students to know science (Llewellyn, 2005). In 2000, the NRC clarified exactly what inquiry encompasses and is essential to teach: conceptual principles and knowledge that guide scientific inquiries; investigations undertaken for a wide variety of reasons–to discover new aspects, explain new phenomena, test conclusions of previous investigations, or test predictions of theories; use of technology to enhance the gathering and analysis of data to results in greater accuracy and precision of the data; use of mathematics and its tools and models for improving the questions, gathering data, constructing explanations, and communicating results; scientific explanations that follow accepted criteria of logically consistent explanation, follow rules of evidence, are open to question and modification, and are based upon historical and current science knowledge; and different types of investigations and results involving public communication within the science community (Barrow, 2006).

Knowledge is not a static entity; rather, it is a dynamic process of inquiry where the learner continuously searches for better understanding of the world (Jarrett, 1997). Students then personally construct their own meaning from their classroom experiences.

When trying to create an inquiry-based student-centered classroom, Llewellyn (2005) stated, “A prerequisite for becoming an inquiry-based teacher is embracing a philosophical mind-set founded on the ideals and principles of constructivism” (p. 27).

Constructivist learning theory. The inquiry learning model is consistent with the constructivist theory, which says that knowledge is constructed by students during their experiences (Dimock & Boethel, 1999). “Constructivism posits that before coming to your class students have had a multitude of unique experiences. As such, individual students bring with them personal beliefs and knowledge about how the world works” (Colburn, 2000, p. 9). John Dewey is considered one of the founders of the constructivist learning theory and said that for a project to truly educate students, it must be interesting to them, should actively involve them, should be meaningful, and should present problems that would require further questioning and inquiry (Marlowe & Page, 2005).

Figure 2 depicts the differences between the traditional classroom and the constructivist classroom.

Traditional Classroom	Constructivist Classroom
Curriculum begins with the parts of the whole. Emphasizes basic skills.	Curriculum emphasizes big concepts, beginning with the whole and expanding to include the parts.
Strict adherence to fixed curriculum is highly valued.	Pursuit of student questions and interests is valued.
Materials are primarily textbooks and workbooks.	Materials include primary sources of material and manipulative materials.
Learning is based on repetition.	Learning is interactive, building on what the student already knows.
Teachers disseminate information to students; students are recipients of knowledge.	Teachers have a dialogue with students, helping students construct their own knowledge.
Teacher's role is directive, rooted in authority.	Teacher's role is interactive, rooted in negotiation.
Assessment is through testing, correct answers.	Assessment includes student works, observations, and points of view, as well as tests. Process is as important as product.
Knowledge is seen as inert.	Knowledge is seen as dynamic, ever changing with our experiences.
Students work primarily alone.	Students work primarily in groups.

Figure 2. Traditional vs. Constructivist Classroom.

The National Science Education Standards developed in 1996 by the NRC defined what effective science teaching looks like and the constructivist tenets that form the basis for their inquiry-based vision (Colburn, 2000). Colburn (2000) also asserted that a constructivist science classroom (1) provides a lab activity and lets students explore instead of telling them what to find, (2) discusses the results of labs before lecturing on the topic, (3) makes students generate their own data and organize their information, (4) places more concept application-type questions on tests, (5) questions students in such a way that their thinking is revealed, (6) requires students to come up with their own lab procedures and questions, and (7) allows students to work in groups where they discuss and share research findings.

Colburn (2000) stated that we must decide how to effectively transition from traditional methods of instruction to constructivist methods of teaching. Silva et al. (2011) advocated the use of a cycle of teaching called the 4MAT cycle, and said that through this process, students actively engage in inquiry activities and in collaborative discussion and designing.

Learning cycle models of instruction. In 1962, Atkin and Karplus first proposed a learning cycle approach to student learning, which was part of the Science Curriculum Improvement Study (Brown & Abell, 2006). “The Learning Cycle was one of the first systematic attempts to outline a sequence of how and when certain ideas in science should be introduced to students in order to promote deep conceptual understanding of scientific ideas” (Songer & Ho, 2005, p. 6). The learning cycle model of teaching and learning is an inquiry-based model where students have more authentic science experiences that mimic what might happen in a real laboratory (Turkmen, 2006). Atkin and Karplus’s (1962) Learning Cycle is depicted in Figure 3, and consists of three phases: exploration, concept development and concept application.

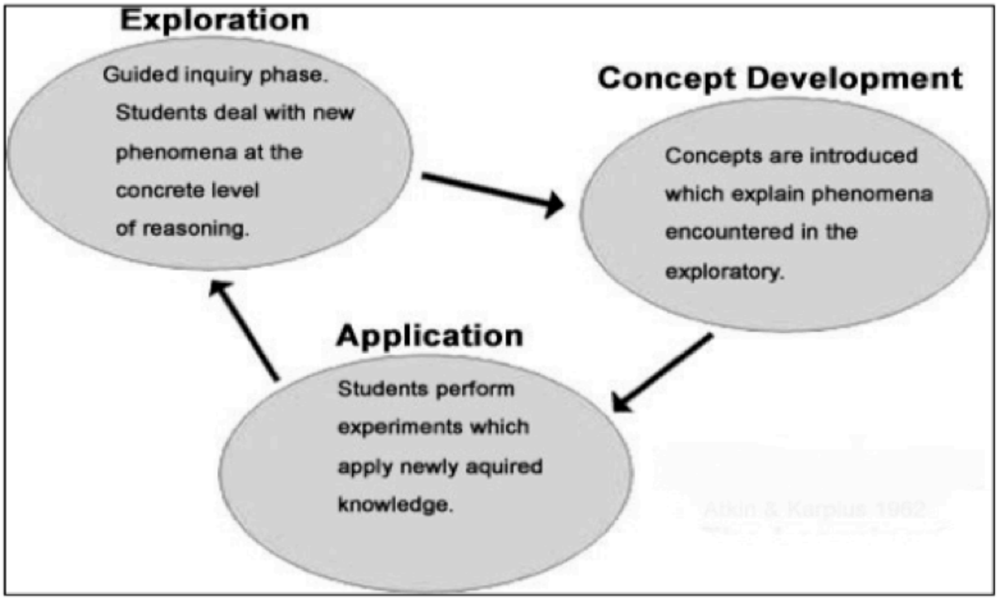

Figure 3. Atkin and Karplus's (1962) 3-Phase Learning Cycle.

This learning cycle was important because it facilitated the change in science learning from studying textbooks to engaging in hands-on experiences (Fuller, 2003). In this model, the first phase is that of exploration of a topic, followed by concept development, and completed by application of knowledge. Several variations of the learning cycle have since been proposed, but each new cycle derives from this original model (Brown & Abell, 2006).

In 1984, David Kolb formulated the experiential learning theory, which says that students create knowledge through a learning cycle consisting of four steps, as opposed to Atkin and Karplus's (1962) three steps (Young, 2002). Figure 4 shows a pictorial version of Kolb's learning cycle. According to Kolb, learning takes place in a four-part cycle: students must first be introduced to the subject through a concrete experience, must reflect on the experience and learn about the subject, must utilize the previous knowledge from steps one and two to practice the knowledge, and last must apply the knowledge gained in steps one through three to a new, authentic situation (Silva et al., 2011).

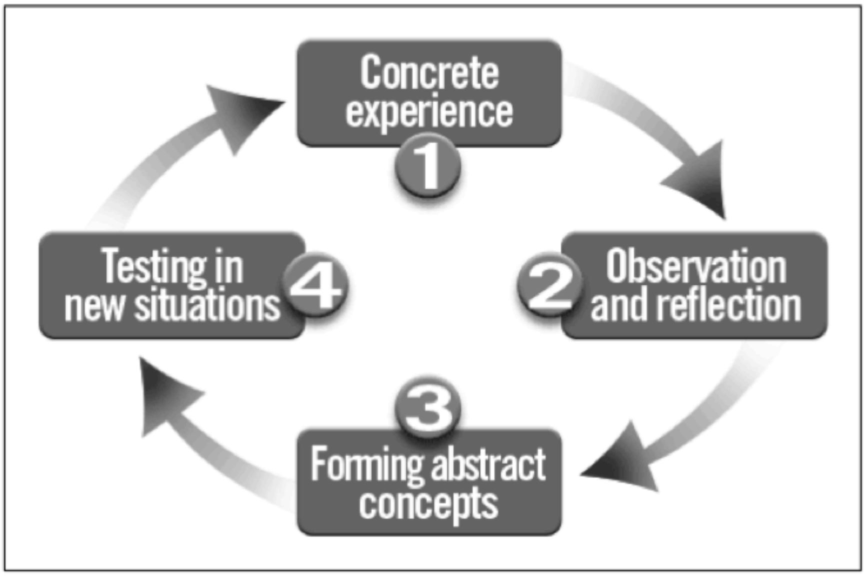

Figure 4. Kolb's (1984) Learning Cycle Model.

In 2006, using Kolb's (1984) learning cycle model as a theoretical basis, Bernice McCarthy (McCarthy & McCarthy, 2006) proposed a new learning cycle that took a holistic approach to learning, the 4MAT cycle (Silva et al., 2011). McCarthy's 4MAT learning cycle was based on three suppositions: (1) different students perceive and process their experiences in different ways, which forms their unique learning styles; (2) students may utilize their left or right brain hemisphere but need to have both sides of the brain engaged; and (3) learning needs to be a combination of the student's body and experiences (Silva et al., 2011). "Engagement with a variety of diverse learning activities results in higher levels of motivation and performance" (Nicoll-Senft & Seider, 2010, p. 19). Figure 5 depicts McCarthy's 4MAT learning cycle model.

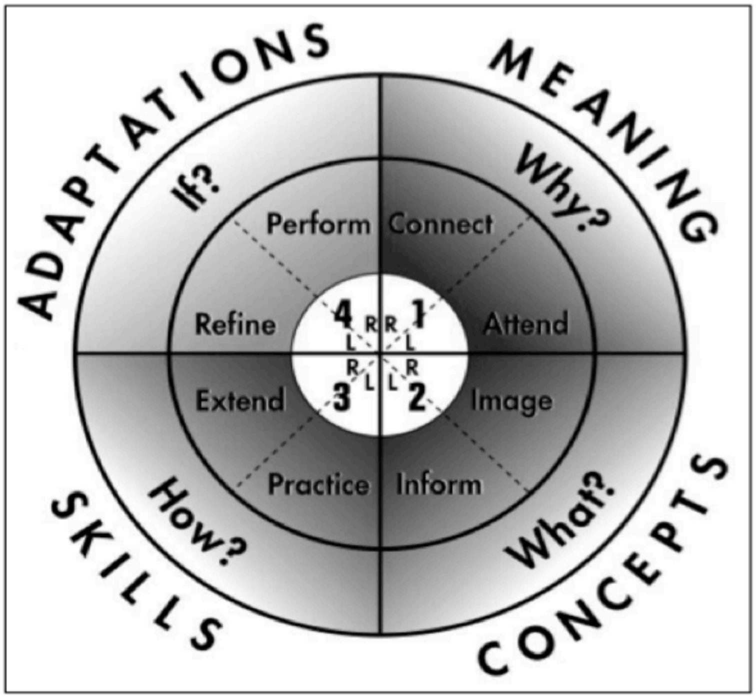

Figure 5. 4MAT Learning Cycle Model.

In the 4MAT learning cycle, each quadrant has its own unique set of activities, and both the right and left hemisphere of the brain are engaged (McCarthy & McCarthy, 2006). In Quadrant 1, the student is provided a hook that engages them and allows them to see how the subject will connect to their real lives. They then reflect on what they have learned. In Quadrant 2, the student is introduced to what the experts say about the subject, and this is where new content is delivered, either at home or in class. In Quadrant 3, the student is encouraged to discover how the material can be relevant to them through practice with the goal of mastery. In Quadrant 4, the student synthesizes all they have learned and presents what they have learned and how it connects to their lives.

Samples, Hammond, and McCarthy (1985) suggested that the 4MAT learning cycle and the subject of science are a natural fit because both emphasized the *wholeness* approach to science, emphasizing not only concepts being studied, but also the discovery component that students need. Further, they said that there are four distinct types of learners and that each quadrant of the 4MAT cycle addresses the needs of one of the four types of learners: innovative learners, analytic learners, common sense learners, and dynamic learners. The innovative learners excel in Quadrant 1 and are learners who require personal meaning as a prerequisite to learning. The analytic learners excel in Quadrant 2 and are those who require facts and information to learn. The common sense learners excel in Quadrant 3 and are those who require action and need to test the information being taught to them. The dynamic learners excel in Quadrant 4 and are those who need to apply and extend their learning (Samples et al., 1985).

Several people have studied the effectiveness of the learning cycle approach to science instruction. Renner, Abraham, and Birnie (1988) proved that students had greater achievement when learning through experiencing first, and then learning the concepts. Gerber, Cavallo, and Marek (2001) showed that students who were taught through the learning-cycle approach in science scored higher on tests of scientific reasoning. In a study of ninth-grade mathematics students, Tatar and Dikici (2009) conducted a study of students in a high school in Turkey. In the control class, the traditional method of instruction was used and in the experimental class, the 4MAT method of instruction was used. They found that the scores of the posttests were higher at a statistically significant level for the experimental group, suggesting that the 4MAT method of instruction produces higher test scores. "Thus, a learning cycle approach helps students make sense of scientific ideas, improve their scientific reasoning, and increase their engagement in science class" (Brown & Abell, 2006, p. 59).

Technology can also be used to supplement the 4MAT learning cycle approach to instruction because it also supports multimodal learning, which supports different learning styles (Turkmen, 2006). In addition, technology, when used along with hands-on instruction, has been shown to increase students' knowledge and attitudes about science (Gardner, Simmons, & Simpson, 1992).

Gerstein (2011) ties technology and the 4MAT cycle together by saying,

> The flipped classroom videos have a place in the models and cycles of learning proposed by educational psychologists and instructional designers. Providing educators with a full framework of how the flipped classroom can be used in their educational settings will increase its validity for educators and their administrators. (p. 6)

Technology use. Dimock and Boethel (1999) found in a review of the literature that computer-based technology can play an important role in a constructivist K-12 learning environment. In 2000, Pryor and Soloway asserted,

> In order for science education to progress beyond the methodology of the nineteenth century, we must integrate technology into the classroom. It is only through the use of technology that education will progress into the needs of the twenty-first century workplace. (p. 5)

Technology-rich, student-centered classrooms are now being defined in terms of what technology they use, how students interact with this technology and each other, and who is in control of the classroom (McPheeters, 2010). McPheeters (2010) also said that time boundaries are now being blurred by communication tools that are asynchronous, such as the Internet. This *blended model* of instruction is one that combines face-to-face class learning with computer-based learning and is the most common model that is emerging today (Clemmitt, 2011).

One of the unintended consequences of using instructional technologies is that the traditional role of the teacher is reshaped from that of lecturer to that of facilitator, creating a more student-centered learning environment (Nworie & Haughton, 2008).

> Technology is a catalyst for change in classroom processes because it provides a distinct departure, a change in context that suggests alternative ways of operating. It can drive a shift from a traditional instructional approach toward a more eclectic set of learning activities that include knowledge-building situations for students. (Sandholtz, Ringstaff, & Dwyer, 1997, p. 47)

In addition, the student-centered learning environment provides the perfect background for supporting both technology and learners (Hannafin & Land, 1997). This type of environment allows students to sample, discover, manipulate, and investigate data. In addition, it encourages authentic knowledge and skills manipulation and emphasizes processes more than traditional approaches (Hannafin & Land, 1997).

Sivin-Kachala, Bialo, and Langford (1998) conducted a meta-analysis that reviewed 219 research studies from 1990 to 1997 to assess what effect technology has had on learning and achievement for all types of students. It was found that students in technology-rich environments had, in all subject areas, positive gains in achievement; that this achievement was true for both regular and special needs students; and that when computers were used in instruction, students had more positive attitudes about not only their learning, but also about their self-concept.

Technology also provides a way for students to collect and organize information in many formats, which allows them to make connections between different facts and events (Sandholtz et al., 1997). Collins and Halverson (2009) proposed that there are a few reasons technology will be useful in the classroom: (1) learning will become more relevant and engaging, (2) computers can customize material for different types of students, and (3) course information can be accessed anywhere and at any time. In addition, when class material is provided through different modalities and sources, students are able to mentally understand the material in a more complex manner (Rosen, 2011).

However, Hannafin and Land (1997) cautioned that "Understanding is best supported when cognitive processes are augmented, not supplanted, by technology" (p. 187). This view was reinforced by Okojie, Olinzock, and Okojie-Boulder (2006) when they said that technology used in instruction should be considered integral to, but not exclusive of, the overall teaching plan. From this, Okojie et al. (2006) defined technology integration as "a process of using existing tools, equipment and materials, including the use of electronic media, for the purpose of enhancing learning" (p. 67).

Technology is a tool that enables inversion of the classroom so that the classroom is not the first point of contact with the new material; the classroom becomes the center of learning (Bowen, 2006). Veneema and Gardner (1996) noted that the use of multimedia methods in presenting course material provides students the opportunity to draw upon their own unique intelligences and advocated the use of an instructional model called the inverted classroom, which flips what traditionally takes place inside the classroom with what traditionally takes place outside of the classroom.

Technological pedagogical content knowledge (TPCK). Mishra and Koehler (2006) asserted that when introducing technology into the classroom, educators tend to focus only on the technology and not the overall framework in which it is used. They further asserted that knowledge of the TPCK framework is crucial construction of good classroom practices and is essential for educators to consider when designing classroom experiences. This includes:

> Understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (Mishra & Koehler, 2006, p. 1029)

The Inverted (Flipped) Classroom

Dimock and Boethel (1999) stated, "both separately and in tandem, constructivism–a learning theory–and technology–an aid to instructional practice–are receiving increasing attention in current efforts at educational reform" (p. 4). The inverted model of the classroom is an inquiry model that fits this type of reform: It is one in which activities that traditionally have taken place inside the classroom, such as lecture, are switched with activities that have traditionally taken place outside the classroom, such as homework (Lage et al., 2000).

> The flipped classroom constitutes a role change for instructors, who give up their front-of-the-class position in favor of a more collaborative and cooperative contribution to the teaching process. There is a concomitant change in the role of students, many of whom are used to being cast as passive participants in the education process, where instruction is served to them. The flipped model puts more of the responsibility for learning on the shoulders of students while giving them greater impetus to experiment. (*7 things*, 2012, p. 2)

In the inverted or flipped model, students are enabled via technology to view lectures outside of class, and then when in class, teachers have the ability to use time that was previously used in lecture to give students the individual help they need to apply and master class material (Brunsell & Horejsi, 2011). In addition, this classroom model provides engagement for a wide variety of student learning styles (Lage et al., 2000). Bowen (2006) discussed how the use of technology makes inversion of the classroom easier; and in this model, the classroom is the center of learning, not just a "passive point of first contact with the material" (p. 6).

When deciding whether or not to flip the classroom, Musallam (2011) suggested that teachers should ask themselves the question, "Given my (teaching) style, do I currently use class time to teach any low-level, procedural, algorithmic concepts? If yes, these are the areas of instruction that could be offset into the home environment via instructional videos" (p. 2).

Bennett, Kern, Gudenrath, and McIntosh (2011) said that a flipped class should have student-led discussions; utilize higher-order thinking; encourage student collaboration; provide authentic content; ensure that students take ownership of their learning; allow the students to expand their knowledge beyond the scope of the curriculum; and have active learning, problem solving, and critical thinking occurring. Bergmann, Overmyer, and Willie (2011) said it is an instructional method where absent students do not get left behind because the out-of-class content is permanently saved for review at the students' convenience, it has a high level of student engagement, and students receive instruction that is personalized to their particular learning style.

One instructional model that incorporates the inquiry model of teaching science and melds well with the flipped classroom model is the 4MAT cycle of learning (Gerstein, 2011). "Embedded in this approach is the constructivist's theory which explains that each new learning combines prior experience and firsthand knowledge gained from new explorations to understand something in greater depth" (Silva et al., 2011, p. 235). Nicoll-Senft and Seider (2010) elaborated and further said that the 4MAT learning cycle method of teaching increases learner engagement and motivation, and gives students more opportunities to practice the application of their learning. Dr. Jackie Gerstein (2011) noted that "the use of video lectures needs to fall within a larger framework of learning activities–within more established models of learning, providing a larger context for educator implementation" (p. 2). By offsetting lecture-type activities into the home environment via teacher-created video, more opportunities are opened up during class time to engage in inquiry learning (Bergmann & Sams, 2012). One method to structure the in-class inquiry component is to use the learning cycle structure in the classroom (Marek, 2008).

In order to maximize the teacher-student interaction in the classroom and to make time for more inquiry-based activities, some direct instruction activities can be moved to the home setting via instructor-created screencasts (Bergmann & Sams, 2012). Often, delivery of class content competes with time teachers need to develop higher-level thinking skills (Todorova & Mills, 2011). In the 4MAT learning cycle approach to science instruction, content is delivered in Quadrant 2 after an engagement activity has occurred in Quadrant 1. One method to offset the delivery of content outside the classroom and maximize hands-on class time is through use of a teacher-created screencast of lecture material.

Screencasting. A screencast is defined as "a way to present digitally recorded playback of computer screen output which often contains audio narration and to visually demonstrate procedural information to students" (Sugar et al., 2010, p. 2). According to Hartsell and Yuen (2006), screencasting is a way to stimulate the visual and auditory senses of students and allow them to learn difficult concepts and procedures. In addition, Folley (2010) stated that students from certain cultural backgrounds may be uncomfortable with a direct questioning mode of instruction; thus, viewing lectures from their home may present a more comfortable environment. There are many types of screencasting software available; some are commercially available, while others are free.

The goal of screencasting is not to replace in-class learning, but to instead supplement and enhance the learning and, in addition, to give students a method of review depending on their needs (Theriault, 2010). In addition, Mayer's pretraining principle of multimedia learning explains that when a large amount of complex information is presented to learners at a fast pace, they are likely to experience cognitive overload (Mayer, 2009; Mayer, Mathias, & Wetzell, 2002). However, to counter cognitive overload, Musallam (2010) said that students who received pretraining via screencast exhibited a statistically significant decrease in the amount of mental effort expended on a posttest versus a pretest of chemistry concepts, thus reducing cognitive load. This is called the pretraining effect.

The learner first encounters the material in Quadrant 1 of the 4MAT cycle through an introductory experiential learning activity before they encounter the expert knowledge of the subject. The first pretraining effect happens here: The experiential activity provides the first exposure to the material during class, providing a context for the screencast of the expert knowledge that the student views at the beginning of Quadrant 2. The second pretraining effect happens when the student begins Quadrant 3 in class. Information from Quadrants 1 and 2 make it easier to process and apply what they have learned when practicing the material (McCarthy & McCarthy, 2006). So the pretraining effect has happened twice–once between Quadrants 1 and 2, and again between Quadrants 2 and 3.

A 3-year study done by Akiyama, Teramoto, and Kozono (2008), in which college students were questioned about watching lectures online, found that 80% of students believed online lectures were preferable for three reasons: (1) they could view the screencasts when it was convenient for them, (2) they could view the screencasts at home, and (3) they could view the screencasts as many times as they needed.

Riffell and Sibley (2005) examined the use of online content to increase the amount of active learning in class time compared to a traditional classroom format for 129 undergraduate biology students. They found that those students viewing online content reported more interaction time with the instructor, were more likely to utilize their textbook, and had grades that matched or excelled those students in the traditional class format.

Traditional, unimodal types of learning have been shown to be less effective than multimodal learning (Fadel & Lemke, 2008). Fadel and Lemke (2008) further stated that having verbal and visual learning taking place simultaneously can result in "significant gains in basic and higher-order thinking" (p. 14).

When designing multimedia instruction, instructional designers now emphasize that cognitive load must be a consideration (Mayer & Moreno, 2003). When creating screencasts for students to view, certain design principles must be adhered to in order to minimize cognitive load. Mayer (2009) has conducted many research studies on multimedia learning, and these are melded into his cognitive theory of multimedia learning.

Cognitive theory of multimedia learning. Research on multimedia interaction reveals that meaningful learning takes place when certain design principles are followed

(Srinivasan & Crooks, 2005). "Meaningful learning outcomes depend on the cognitive activity of the learner during learning rather than on the learner's behavioral activity during learning" (Mayer, 2009, p. 3). In addition, many experiments have demonstrated that by integrating multiple sources of information, cognitive load can be reduced (Chandler & Sweller, 1992; Sweller, Chandler, Tierney, & Cooper, 1990; van Merrienboer & Sweller, 2005; Ward & Sweller, 1990). The size of a student's working memory can be increased by presenting information in mixed modes–auditory and visual–rather than only in one mode (Fadel & Lemke, 2008; Mousavi, Low, & Sweller, 1995). Based on the work of Paivio (1986), Baddeley (1986), and Sweller (1999), Mayer (2009) proposed a multimedia model that explained how people learn, shown in Figure 6.

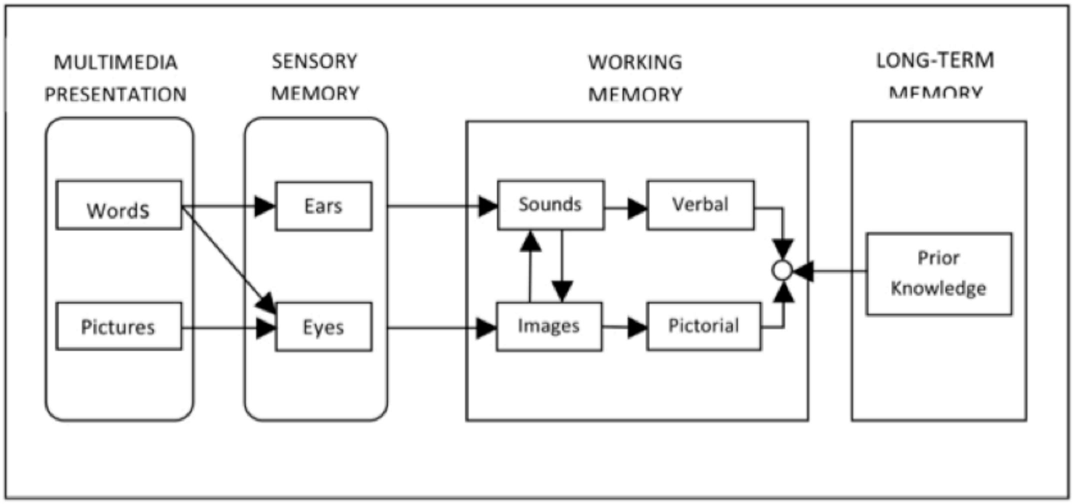

Figure 6. Mayer's (1998) Multimedia Model.

Based on his cognitive theory of multimedia learning presented in Figure 6, Mayer (2009) proposed some principles to be considered when designing multimedia instruction to reduce cognitive load. The Multimedia Principle says that students learn better when words and pictures are presented as opposed to words alone; the Spatial Contiguity Principle says that students learn better when the words and pictures are near each other on the screen; the Temporal Contiguity Principle says that students learn better when words and pictures are presented at the same time as opposed to at different times; the Coherence Principle says that students learn better when extraneous words, sounds and pictures are omitted from the screen; the Modality Principle says students learn better from narration coupled with animation than from on-screen words and animation; and the Redundancy Principle says students learn better from animation and narration without words on the screen.

Creation of screencasts, according to Mayer's (2009) multimedia model, ensures that students' verbal and visual channels work together to reduce the cognitive load students could otherwise experience with use of only one channel.

Sugar et al. (2010) noted that screencasts could replace lecture in the classroom for a number of lecture types. The first, overview, is a strategy that can be used to give a rationale for engaging in the topic and to provide some background information needed to move forward. The second is to describe a procedure. The third is to present a concept or provide content lecture. The fourth is to focus attention on a certain portion of a concept that is particularly difficult to understand. The fifth is to provide elaboration of content or to provide enrichment. Sugar et al. recommended that eliciting student perceptions of the different instructional strategies used in screencasting would be a good direction for future research since little is known about the subject.

When researching the effectiveness of different classroom instructional strategies, one type of research particularly suited to conducting research into effecting change in the classroom is the action research method (Pine, 2009).

Action Research

Action research is a method of inquiry that educators can use to examine their own practice in the classroom setting. Pine (2009) said, "Characteristically, action research studies a problematic situation in an ongoing systematic and recursive way to take action to change that situation" (p. 30). In action research, often the researcher is an insider in an organization who undertakes research not only to gain knowledge about a problem, but also to serve as personal professional development (Herr & Anderson, 2005). The ultimate goal of action research is that "data analysis is pushed by relevant literature and the literature should be extended through the contribution of this action research" (Herr & Anderson, 2005, p. 84).

Five phases are included in the action research cycle: identification of problem area, collection and organization of data, interpretation of data, action based on data, and reflection (Ferrance, 2000). There are multiple types of data that can be collected in this type of research: Examples are interviews, portfolios, journals, surveys, focus groups, and classroom records (Ferrance, 2000).

Two important parts in an action research project that help to establish credibility of the research are validity and reliability (Johnson, 2005). Validity refers to how well the collected data actually measures what it is trying to measure; reliability refers to how easily replicable the study is (Johnson, 2005). These can both be established by triangulation of data, which provides a deeper understanding of all sides of the issue, thus, enhancing accuracy and credibility. Triangulation of data involves collecting different types of data and utilizing differing data sources to ensure validity and reliability (Johnson, 2005).

One type of research design in action research is the quasi-experimental research design in which the learning environment is manipulated (Johnson, 2005). A way of conducting this type of research is to compare data from two similar groups of students, usually with a pre and posttest. When groups are not randomly assigned, the two groups could be different prior to the study (Trochim, 2006). Because any differences cannot be controlled experimentally, and so that these differences do not affect the outcome of the study, comparison of the pre and posttest means by paired t tests of both groups should be scrutinized (Horn, 2011). If a difference exists, then an analysis of covariance (ANCOVA) test can be performed (Johnson, 2005). This test adjusts the posttest means for differences in groups on the pretest.

Mertler (2006) cited a few benefits of action research in the classroom: It is reflective, which allows the researcher to refine and change their teaching practice as needed; it affords the researcher a method for professional growth; and it leads to decision making carried out at the classroom level, which further leads to teacher empowerment.

Summary

Because today's students have different learning styles and come from different backgrounds, it is crucial that educators shift from a teacher-centered approach to a student-centered approach to teaching and learning. Bellanca and Brandt (2010) noted that

> The forces instigating the inevitable changes on the horizon in education have been building for some time: the world is changing, U.S. schools and students have not adapted to the changing world, and the United States has no clear sense of purpose or direction for securing our future economic competitiveness. (p. xvii)

Constructivism is now making a significant impact on educational reform and is considered an important theory about how students learn (Llewellyn, 2005). There has been a shift in education from textbooks and lectures to constructivist teaching and learning technologies, which opens up more class time to meet individual student needs (Bonk, 2009). The flipped classroom is a teaching model where, through the use of technology, passive learning can be offset to the home environment and active learning or inquiry can take place in the student-centered classroom, thus enabling students to garner the 21st Century skills that are necessary in today's workplace.

In Chapter 3, the methodology of the action research study is presented, including discussion of the participants and their demographic data, the instruments utilized, and the procedures used to conduct the study.

Chapter 3: Methodology

Introduction

The purpose of this action research study was to compare the effects of two models of instructional delivery, the traditional model of delivery and the inverted model of delivery, on achievement gains in two Physical Science Honors classes as measured by statistical significance of scores on pre- and post-unit tests within a unit of study. In addition, students', parents', and instructor's perceptions about the inverted method of instruction were gathered and analyzed to ascertain how successful they feel the model is and which strategies best enable students to succeed.

The research questions to be answered in this study were:

1. Within the 4MAT model of inquiry-based instruction, what are the effects of an inverted instructional model of delivery on the performance of ninth-grade Physical Science Honors students as compared to traditionally delivered instruction?
2. What are students' perceptions of the inverted instructional model of delivery?
3. What are parents' perceptions of the inverted instructional model of delivery?
4. What are the instructor's perceptions of the inverted instructional model of delivery?

Participants

The population that was studied came from a rural high school in the southern United States. There were approximately 2,100 students in this school, and the racial/ethnic makeup consisted of approximately 62.5% Caucasian, 33% African American, 3.4% Hispanic, and other races. Additionally, approximately 63% of the students received free or reduced-price lunches. Available technology for student use included three computer labs, one or more computers in each classroom, and a mobile laptop lab and mobile iPad lab for checkout by teachers.

The students in the study were ninth-grade Physical Science Honors students. The researcher had two classes of Physical Science Honors: The first class in the day was designated as the traditional delivery or control class; the second was the inverted delivery or experimental class. These were assigned randomly in the summer when the schedule was finished and before any student rosters were created. All students with parental permission in the experimental class participated in the online survey process at the end of the research study and also participated in student focus groups. Additionally, students with parents' permission in both classes participated in the pre and posttest statistical analysis. Parents of the experimental group also assisted in providing perceptual data through online survey. The complete flow of participants throughout the study is contained in Appendix A.

In both classrooms, the 4MAT learning cycle method was utilized in which students began with an exploratory activity to introduce the concept (Quadrant 1), received the expert knowledge on the subject via lecture (Quadrant 2), completed reinforcement practice activities (Quadrant 3), and concluded the learning cycle by completing inquiry labs and presenting their group findings to the class for reflective discussion (Quadrant 4).

In the traditionally delivered, or control class, however, the two components of new material lecture, homework review, pre-lab instruction, and extra help instruction occurred within the classroom setting. All classroom materials were stored on the class webpage, as has been done in the past, to include class notes, PowerPoint lectures, extra help worksheets, and other materials as needed. These were accessible by the students any time on the teacher website (Appendix B).

In contrast, in the inverted delivery model, or experimental class, the Quadrant 2 components of new material lecture, pre-lab instruction, homework review, and extra help instruction occurred outside of the classroom setting via screencast. Screencasts were created that utilized Mayer's (1998) Cognitive Theory of Multimedia Learning principles to minimize cognitive overload. Screencasts were stored on the password-protected class website, via links to YouTube, and could be accessed via computer, smartphone, tablet, or other suitable device anywhere and at any time (Appendix C). To accommodate students who might not have access to the Internet in the home setting, videos were offered in the format of CD, DVD, or flash drive.

Because the study began about one-half way through the fall semester, the students in both classes had time to become accustomed to the 4MAT method of instruction and, in addition, the students in the experimental class had time to become familiar with how screencasting works at home and what was the best method for them to access the material. By the time the research started, both groups were familiar with what was expected of them. This helped mitigate the effects of the students' learning curve in learning a new classroom delivery format.

Instruments

Four types of instruments were utilized to gather and triangulate data in this study. For the first instrument, the pre and post-unit tests, the researcher utilized existing course pre and posttests of questions already created, validated, and released by various states from their EOC tests in Physical Science based on the state standards.

The second instrument utilized was the Student Online Survey (Appendix D), which was created by myself due to lack of existing pertinent instrumentation in the literature. This survey consisted of demographic as well as multiple-choice statements the student must answer regarding their perceptions of the inverted classroom. Anderson and Bourke (2000) suggested that once a survey has been created, five qualities should be examined. The first is communication value, or how easily understood the instrument is for its intended audience. The second is objectivity, or the degree to which the final coded answers are free of researcher bias. The third is validity, or the degree to which the survey actually measures what it is intended to measure. The fourth is reliability, or consistency of the information obtained by the survey. The fifth is interpretability, or how easily understood the gathered data is. In this study, the Student Online Survey was scrutinized and critiqued by experts in the area of the inverted classroom: Dr. Ramsey Musallam, AP Chemistry teacher and Department Chair at Sacred Heart Cathedral Preparatory School in San Francisco, California, and author of numerous articles, blogs, and websites on flipping the classroom; Mr. Jonathan Bergmann, co-author of the book "Flip Your Classroom" and recipient of the Presidential Award for Excellence in Math and Science Teaching in 2009; Mr. Greg Green, Principal of the first completely flipped high school, Clintondale High School in Clinton Township, Michigan; Mrs. Kim Wiest, AP Chemistry teacher in Governor Mifflin School District in Pennsylvania and author of a flipped class blog on the University of Northern Colorado's Educational Vodcasting website; and Mr. Jerry Overmeyer of the Math and Science Teaching Institute at the University of Northern Colorado and author of the Educational Vodcasting website. Questions were modified or discarded based on feedback from these experts.

The third instrument, the Parent Online Survey (Appendix E), was also created by myself due to lack of pertinent instrumentation in the literature. This survey consisted of multiple-choice perceptual questions the parents must answer. To validate this survey, an independent group of parents from my school scrutinized and critiqued the instrument, and the questions were modified or discarded as indicated.

The fourth type of instrument utilized was the Student Focus Group Questions (Appendix F). These questions were developed by myself as a further extension of the validated surveys, were open-ended, and addressed any questions arising from the survey data.

The last type of instrument was my Daily Reflective Journal. I not only recorded all activities within the learning cycle in which the students engaged but also considered the following focal questions for journaling suggested by Pine (2009):

1. Was my teaching effective in promoting learning by students?
2. What aspects of my teaching did I consider successful?
3. What aspects of my teaching did I feel needed improvement?
4. What conditions were important to student learning?
5. Were there any unanticipated learning outcomes? How did they affect the students?

Other insights were recorded as appropriate.

Procedures

This action research study was a quasi-experimental mixed-methods study, employing both quantitative and qualitative methodologies. Bell et al. (2008) synthesized the findings of four studies that prove "an emerging and promising trend in the research on technology use in science education to affect student achievement is the mixed-methods approach" (p. 36). Bell et al. further stated that the combination of quantitative and qualitative data provide a more complete picture of overall student achievement. Additionally, Ferrance (2000) stated that action research, done in a teacher's classroom, "helps to confer relevance and validity to a disciplined study" (p.

13).

To answer the research questions, I taught both classes with the 4MAT learning cycle teaching method. The main difference between the two classes was how the students received their material: The control class received lecture material in class and completed homework material at home; the experimental class received lecture material at home via screencast and completed homework material in class. My teacher website (Appendix B) was maintained to house all of the teacher-created materials: For the control class, PowerPoint presentations, notes, and review guides were available for students to use; for the experimental class, teacher-created screencasts of the PowerPoints, class notes, and review guides were available at all times.

Question 1, "Within the 4MAT model of inquiry-based instruction, what are the effects of an inverted instructional model of delivery on the performance of ninth-grade Physical Science Honors students as compared to traditionally delivered instruction," was answered quantitatively by comparing pre-unit tests that were already in place for students in both the experimental and the control classes at the beginning of the unit to be measured to the exact same post-unit tests at the end of the unit to be measured. An independent t test was performed on the means of both groups to assess whether there was a difference in prior knowledge between the two groups. Analysis of the posttest consisted of an independent t test to look for differences in performance between the experimental and control groups at a statistically significant level. Question 2, "What are students' perceptions of the inverted instructional model of delivery," was answered qualitatively by online survey of students in the experimental class, as well as focus groups of students in the experimental class. The survey was developed by myself and consisted of questions in a multiple-choice type format. Results of the survey were tallied and presented in data tables. I also developed the open-ended focus group questions as extensions of the student survey. The focus group discussions were audiotape recorded and transcribed, using no identifying student information, and the data was reduced into themes by the coding process and analyzed and represented in figure, table, and narrative form. Question 3, "What are parents' perceptions of the inverted instructional model of delivery," was answered qualitatively by survey of parents of students in the experimental class. This survey consisted of questions in a multiple choice and free response online format; multiple choice data was tallied and presented in a data table, while the free response data was reduced into themes by the coding process, analyzed, and represented in figure, table, and narrative form. Question 4, "What are the instructor's perceptions of the inverted instructional model of delivery," was answered qualitatively via a reflective journal in which I kept journal entries. Data were reduced into themes by the coding process, analyzed, and represented in figure, table, and narrative form and compared to data collected from parents and students.

At the conclusion of the study, data were scrutinized and classroom teaching was revised and refined as indicated by data and student/parent perceptions.

Limitations and Delimitations

One limitation of this study was that only a limited number of students were involved in the study due to my assigned class schedule, and the testing period was limited. I only studied one school in a rural part of the United States, so the results may not be generalizable for all ninth-grade Physical Science Honors students. However, Pine (2009) said that "evidence and conclusions from action research studies are generalizable in the traditional sense, even for single case studies" (p. 90). Pine also argued that if, through action research, a researcher determines that a particular method or curriculum works well, then it makes sense that it could be generalizable to other similar situations. Lomax (1994) further stated that this type of generalization can be accomplished if the researcher makes their research process transparent to outsiders so they have enough information to decide if the research applies to their situation. Another limitation is the fact that the school blocks YouTube, which is needed to view the instructional videos I created.

One delimitation of the study is that I used the 4MAT learning cycle for the in-class portion of the study and utilized the inverted classroom model of delivery for the out-of-class portion of the study; therefore, results are only generalizable for this particular combination of teaching strategies.

Summary

The purpose of this study was to compare the effects of using the traditional teaching delivery model to the flipped teaching delivery model. This action research mixed-methods design not only allowed me to gather quantitative data of student performance but also to investigate stakeholder's perceptions of the teaching model as a whole.

My intent in conducting this study was to investigate and report the results of utilizing a flipped or inverted classroom model to promote learning skills and outcomes that will increase student achievement in a science class.

In Chapter 4, the data collection and analysis procedures for each research question are presented and common themes among all data are identified. Descriptive demographics are discussed, as are all research findings.

Chapter 4: Results

The purpose of this action research study was to compare the effects of two models of instructional delivery, the traditional model of delivery and the inverted model of delivery, on achievement gains in two Physical Science Honors classes as measured by statistical significance of scores on pre and post-unit tests within two units of study. In addition, students', parents', and instructor's perceptions about the inverted method of instruction were gathered and analyzed to ascertain how successful they felt the model was and which strategies best enabled students to succeed.

The research questions to be answered in this study were:

1. Within the 4MAT model of inquiry-based instruction, what are the effects of an inverted instructional model of delivery on the performance of ninth-grade Physical Science Honors students as compared to traditionally delivered instruction?

2. What are students' perceptions of the inverted instructional model of delivery?

3. What are parents' perceptions of the inverted instructional model of delivery?

4. What are the instructor's perceptions of the inverted instructional model of delivery?

The independent variable for this study was the format of lecture delivery: flipped versus traditional. The dependent variable for Research Question 1 was student achievement as measured by pre and posttests of the instructional units; the dependent variable for Research Questions 2, 3, and 4 was the perceptions of the various stakeholders in the study.

Both classes were taught with the 4MAT learning cycle model. However, the lecture format differed. In the experimental class, the lecture format was delivered via video outside the classroom setting. In the control class, the lecture format was delivered in the traditional in-class format. The flow of all participants throughout the study is documented in Appendix A.

The remainder of this chapter presents the data collection and analysis procedures, descriptive demographics of the participants in the study, and the research findings for each of the four research questions.

Data Collection Procedures

The data gathered included the pre and post-unit test scores for the first semester of 2012. Two units were covered during the period of the study. Unit 1, Forces and Motion, consisted of the subtopics Newton's first, second, and third laws and lasted for 3½ weeks. Unit 2, Energy, consisted of the subtopics energy, thermal energy, work, power, electricity, and magnetism and lasted for 6½ weeks. At the beginning of each unit, students were given a preexisting pretest to assess prior knowledge. Test items consisted of previously validated questions on Physical Science EOC tests released by various states. At the completion of the unit, students were given the posttest, which was the exact same test as the pretest.

At the completion of the study, students in the experimental class completed a validated online survey. As a further extension of the survey, I conducted a focus group of students in the experimental class after the surveys were complete. The focus group was audio recorded, and students' comments were transcribed word-for-word, using only numbers as identifiers. In addition, at the completion of the study, parents of students in the experimental class completed a validated online survey. In addition, I kept a reflective journal that documented my activities and my observations as the study progressed.

Data Analysis Procedures

The quantitative data analysis that was employed for Research Question 1, "Within the 4MAT model of inquiry-based instruction, what are the effects of an inverted instructional model of delivery on the performance of ninth-grade Physical Science Honors students as compared to traditionally delivered instruction," in this study utilized Microsoft Excel 2007 data analysis package. Descriptive statistics were completed for all quantitative data collected to include the number of responses (*N*), mean (*M*), and standard deviation (*SD*). In addition, independent t-test inferential statistics were conducted on the pre and posttest data.

To begin with, two-sample, two-tailed independent t tests (assuming equal variances) were performed on the pretest data for both classes for each unit to determine if any difference in prior knowledge existed between the two classes at the alpha significance level of 0.05. There were no significant differences in prior knowledge for the two classes on either of the two unit pretests. Next, the same independent t test was performed on the posttest data for both classes for each of the two units.

Following the collection of all qualitative data, data from Research Question 2 (What are students' perceptions of the inverted instructional model of delivery?), Research Question 3 (What are parents' perceptions of the inverted instructional model of delivery?), and Research Question 4 (What are the instructor's perceptions of the inverted instructional model of delivery?) were transcribed and analyzed. I compared data from these three sources to identify the common themes, and six major themes emerged. The results of the data analysis will appear in the discussion related to each research question.

Descriptive Demographics

Demographic data were collected on students in both the experimental and the control classes to include gender, race/ethnic group, and lunch status, which is an indication of the poverty index for the school. The purpose of gathering this data was to provide a clear picture of the types of students enrolled in each class and to allow for disaggregation of data.

Figure 7 depicts gender data between the control and experimental classes based on total number of students in each class.

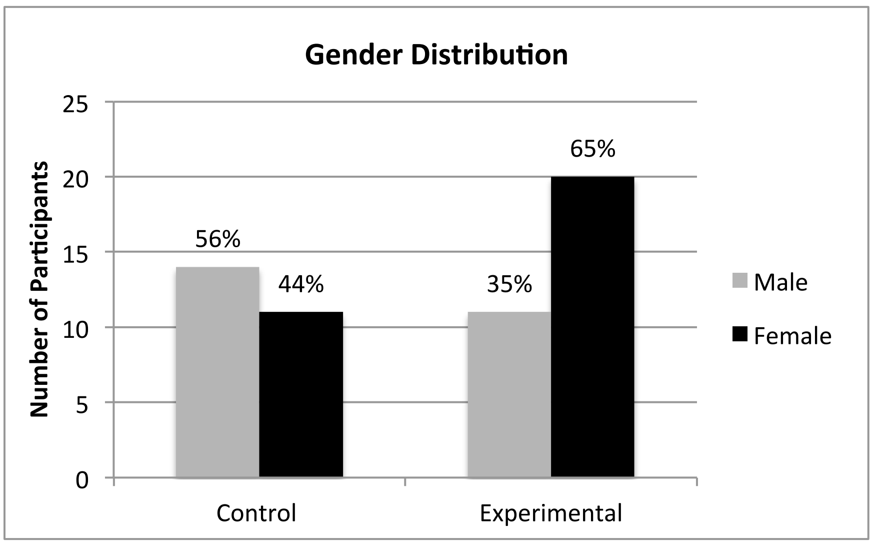

Figure 7. Gender Distribution.

Figure 8 depicts race/ethnicity data between control and experimental classes based on the total number of students in each class. Percentages for each class add up to 100%.

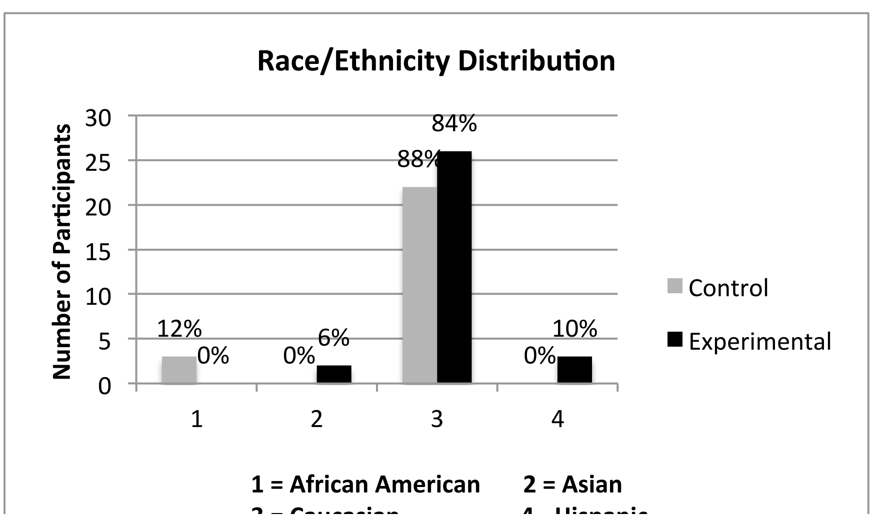

Figure 8. Race/Ethnicity Distribution.

Figure 9 depicts lunch status data, which is an indicator of the socioeconomic level of the students based on total number of students in each class. Percentages for each class add up to 100%.

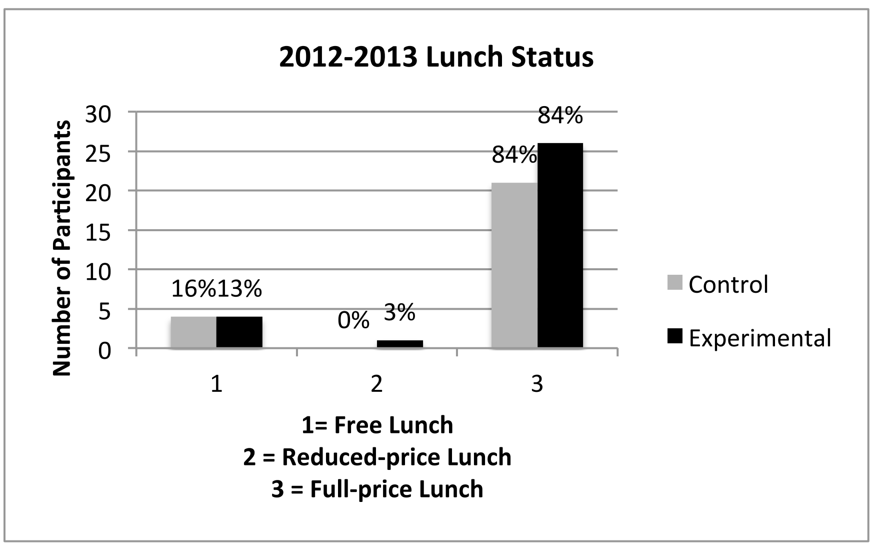

Figure 9. 2012-2013 Lunch Status.

Findings for Research Question 1

Research Question 1 asked, "Within the 4MAT model of inquiry-based instruction, what are the effects of an inverted instructional model of delivery on the performance of ninth-grade Physical Science Honors students as compared to traditionally delivered instruction?" For this research question, the independent variable is the format of lecture delivery; the dependent variable is the pre and posttest score. The null hypothesis is lecture delivery outside the classroom will have no significant effect on the performance of students on the pre and posttests. The alternate hypothesis is lecture delivery outside the classroom will have a significant effect on the performance of students on the pre and posttests.

Pretest statistics. To ascertain whether or not there was a significant difference in knowledge between the control and experimental classes before each unit began, an independent t test was performed on the pretest results to see if there was a difference in prior knowledge for each unit. Group statistics are reported in Table 2 and t-test results are reported in Table 3.

Table 2

Group Statistics for Control and Experimental Groups on Pretest Results

Pretest Unit 1	Group	N	# Quest	Mean	SD
	Control	25	28	12.16	2.94
	Experimental	31	28	13.90	3.75

Pretest Unit 2	Group	N	#Quest	Mean	SD
	Control	25	26	10.32	2.89
	Experimental	31	26	10.48	2.91

Table 3

Independent t-test Results for Equality of Means of Prior Knowledge on Pretests

Equal Variances Assumed	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	1	-1.99	52	2.01	.05
	2	-0.16	52	2.01	.87

For Unit 1 there was no significant effect for prior knowledge, $t(52) = 1.99$, $p = .05$ between the control and experimental class. For Unit 2 there was also no significant effect for prior knowledge, $t(52) = .16$, $p = .87$. Therefore, for both pretests, no significant difference existed in prior knowledge.

Posttest statistics. The next step was to perform independent t tests on the posttest data for both units to ascertain if the lecture delivery format had a significant effect on gain scores for both groups. Group statistics, including average gain score, are reported in Table 4 and t-test results are reported in Table 5.

Table 4

Group Statistics for Control and Experimental Groups on Posttest Results

Posttest Unit 1	Group	N	Mean	SD	Avg. Gain
	Control	25	29.68	2.76	6.96
	Experimental	31	20.84	4.41	9.94
Posttest Unit 2	Group	N	Mean	SD	Avg. Gain
	Control	25	14.84	2.49	4.92
	Experimental	31	16.06	3.66	5.58

Table 5

Independent t-test Results for Equality of Means on Unit Posttests

Equal Variances Assumed	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	1	-1.35	52	2.01	0.18
Alpha = .05	2	-1.56	52	2.01	0.13

For Unit 1 there was no significant effect of the treatment on the posttest results between the control and experimental class, $t(52) = 1.35$, $p = .18$. For Unit 2 there was also no significant effect of the treatment, $t(52) = 1.56$, $p = .13$. Therefore, for both posttests, no significant difference existed due to the independent variable. This resulted in a failure to reject the null hypothesis for both units.

In addition, independent t tests were completed on disaggregated average gain data by gender, race/ethnicity, and lunch status to determine if lecture delivery format had a significant effect on gain scores for both groups.

Gender statistics. Table 6 shows the average gain scores for males versus females for both units.

Table 6

Average Gain Scores for Males vs. Females: Experimental and Control Classes

		Male	Female
Experimental (n: M = 11; F = 20)	Unit 1	6.73	7.05
	Unit 2	3.64	6.15
Control (n: M = 14; F = 11)	Unit 1	8.00	7.09
	Unit 2	3.79	5.45

Table 7 shows the independent t-test results on the average gain scores of males versus females.

Table 7

Independent t-test Results for Equality of Means on Average Gain Scores: Males vs. Females

Equal Variances Assumed	Class	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	Experimental	1	0.22	29	2.05	0.82
		2	1.76	29	2.05	0.09
Alpha = 0.05	Control	1	-0.63	23	2.07	0.54
		2	1.27	23	2.07	0.22

By gender, for the experimental class, there was no significant difference on the average gain scores between males and females for Unit 1 or Unit 2, $t(29) = 0.22$, $p = .82$ and $t(29) = 1.76$, $p = 0.09$, respectively. By gender, for the control class, there was also no significant effect of the treatment on the average gain scores between males and females for Unit 1 or Unit 2, $t(23) = 0.63$, $p = 0.54$ and $t(23) = 1.27$, $p = 0.22$, respectively.

Table 8 shows the independent t-test results on the average gain scores of males in the control class versus males in the experimental class.

Table 8

Independent t-test Results for Equality of Means on Average Gain Scores: Control vs. Experimental Males

Equal Variances Assumed	Unit	t Stat	df	t Crit (2 tailed)	p
	1	0.99	23	2.07	0.33
	2	0.09	23	2.07	0.93
Alpha = 0.05					

For the control class males versus the experimental class males, there was no significant difference on the average gain scores for Unit 1 or Unit 2, $t(23) = 0.99$, $p = .33$ and $t(23) = 0.09$, $p = 0.93$, respectively.

Table 9 shows the independent t-test results on the average gain scores of females in the control class versus females in the experimental class.

Table 9

Independent t-test Results for Equality of Means on Average Gain Scores: Control vs. Experimental Females

Equal Variances Assumed	Unit	t Stat	df	t Crit (2 tailed)	p
	2	-0.63	29	2.05	0.53
Alpha = 0.05					

For the control class females versus the experimental class females, there was no significant difference on the average gain scores for Unit 1 or Unit 2, $t(29) = 0.03$, $p =$

.98 and $t(29) = 0.63$, $p = 0.53$, respectively.

To summarize, there is no significant difference between males and females in the experimental versus the control class. In addition, when comparing males in experimental and control classes and females in experimental and control classes, there was no significant difference in performance.

Race/ethnicity statistics. Independent t tests were also completed on disaggregated average gain data by race/ethnicity to determine if lecture delivery format had a significant effect on gain scores for both groups. Since there were very few minorities in the two classes, I compared Caucasian students to African-American, Asian, and Hispanic students grouped together. Table 10 shows the group statistics for Caucasian vs. Other for the average gain scores broken down by race/ethnicity.

Table 10

Average Gain Scores for Caucasian vs. Other: Experimental and Control Classes

		Caucasian	Other
Experimental (n: C = 26; O = 5)	Unit 1	7.58	3.80
	Unit 2	5.77	5.60
Control (n: C = 22; O = 3)	Unit 1	7.36	8.67
	Unit 2	4.18	7.00

Table 11 shows the independent t-test results on the average gain scores of Caucasians versus Other Race/Ethnicities (African American, Asian, Hispanic).

Table 11

Independent t-test Results for Equality of Means on Average Gain Scores: Caucasian vs. Other Race/Ethnicities

Equal Variances Assumed	Class	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	Experimental	1	2.15	29	2.05	0.04
		2	-0.01	29	2.05	0.99
Alpha – 0.05	Control	1	-0.60	23	2.07	0.56
		2	-1.42	23	2.07	0.17

By race/ethnicity for the experimental class, for Unit 1, there was a significant difference between the average gain scores for Caucasian versus Other Race/Ethnicities, $t(29) = 2.15$, $p = 0.04$ with the Caucasians outperforming the other races/ethnicities. However, for Unit 2, there was no significant difference on the average gain scores between Caucasians and Other Race/Ethnicities, $t(29) = 0.01$, $p = .99$. By race/ethnicity for the control class, for Unit 1 and Unit 2, there was no significant difference between average gain scores for Caucasian vs. Other Race/Ethnicities $t(23) = 0.60$, $p = .56$, and $t(23) = 1.42$, $p = 0.17$, respectively.

Next Caucasians were compared in the control class versus the experimental class. Table 12 shows the independent t-test results on the average gain scores.

Table 12

Independent t-test Results for Equality of Means on Average Gain Scores: Control vs. Experimental Caucasians

Equal Variances Assumed	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	1	-0.22	46	2.01	0.83
	2	-1.48	46	2.01	0.15
Alpha = 0.05					

For the control versus the experimental class of Caucasians, there was no significant difference on the average gain scores for Unit 1 or Unit 2, $t(46) = 0.22$, $p = .83$ and $t(46) = 1.48$, $p = 0.15$, respectively.

Table 13 shows the independent t-test results on the average gain scores of Other Races/Ethnicities (Asian, African American, Hispanic) in the control class versus the experimental class.

Table 13

Independent t-test Results for Equality of Means on Average Gain Scores: Control vs. Experimental Other Races/Ethnicities

Equal Variances Assumed	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	1	1.32	6	2.45	0.24
	2	0.56	6	2.45	0.59
Alpha = 0.05					

For Other Races/Ethnicities, control versus the experimental class, there was no significant difference on the average gain scores for Unit 1 or Unit 2, $t(6) = 1.32$, $p = .24$ and $t(6) = 0.56$, $p = 0.59$, respectively.

In summary, when Caucasians were compared to the other races/ethnicities, there was no significant difference in performance except in one instance, Unit 1, where Caucasians outperformed the other races/ethnicities at a statistically significant level. In addition, there is no statistically significant difference between Caucasians in the control versus experimental class, nor for other races/ethnicities in the control versus experimental class.

Lunch status statistics. Last, independent t tests were completed on disaggregated average gain data by lunch status to determine if lecture delivery format had a significant effect on gain scores for both groups. Full-price lunch students' scores were compared to free and reduced-price lunch students' average gain scores. Table 14 shows the group statistics for full-price versus free/reduced-price lunch students for the average gain scores.

Table 14

Average Gain Scores for Free/Reduced-Price Lunch vs. Full-Price Lunch: Experimental and Control Classes

		Free/Reduced	Full
Experimental (n: F/R = 5; Full = 26)	Unit 1	7.60	6.81
	Unit 2	4.60	5.77
Control (n: F/R = 4; Full = 21)	Unit 1	8.00	7.43
	Unit 2	5.00	4.43

Table 15 shows the independent t-test results on the average gain scores of students who have full-price lunch versus students who have free/reduced-price lunch.

Table 15

Independent t-test Results for Equality of Means on Average Gain Scores: Free/Reduced-Price Lunch vs. Full-Price Lunch

Equal Variances Assumed	Class	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	Experimental	1	0.42	29	2.05	0.68
		2	-0.73	29	2.05	0.47
Alpha = 0.05	Control	1	0.29	23	2.07	0.77
		2	0.31	23	2.07	0.76

By lunch status, for the experimental class, Units 1 and 2, there was no significant difference between the average gain scores of students who had full-price lunch versus students who had free/reduced-price lunch, $t(29) = 0.42$, $p = .68$ and $t(29) = 0.73$, $p = .47$, respectively. By lunch status, for the control class, Units 1 and 2, there was also no significant difference between the average gain scores of students who had full-price lunch versus students who had free/reduced-price lunch, $t(23) = 0.29$, $p = 0.77$, and $t(23) = 0.31$, $p = 0.76$, respectively.

Table 16 shows the independent t-test results on the average gain scores based on lunch status for free and reduced-price lunch, control vs. experimental classes.

Table 16

Independent t-test Results for Equality of Means on Average Gain Scores: Control vs. Experimental Free/Reduced-Price Lunch Status

Equal Variances Assumed	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	1	0.16	7	2.36	0.88
Alpha = 0.05	2	0.25	7	2.36	0.81

For the control class versus experimental class free/reduced-price lunch students, there was no significant difference on the average gain scores for Unit 1 or Unit 2, $t(7) = 0.16$, $p = .88$and $t(7) = 0.25$, $p = 0.81$, respectively.

Table 17 shows the independent t-test results on the average gain scores of students who pay full-price for their lunch in the control class versus the experimental class.

Table 17

Independent t-test Results for Equality of Means on Average Gain Scores: Control vs. Experimental Full-Price Lunch Status

Equal Variances Assumed	Unit	*t* Stat	df	*t* Crit (2 tailed)	*p*
	1	0.57	45	2.01	0.57
	2	-1.33	45	2.01	0.19
Alpha = 0.05					

For the control class versus the experimental class of full-price lunch students, there was no significant difference on the average gain scores for Unit 1 or Unit 2, $t(45) = 0.57$, $p = .57$ and $t(45) = 1.33$, $p = 0.19$, respectively.

In summary, there is no significant difference between students with free/reduced-price lunch status versus students with full-price lunch status. In addition, there is no statistically significant difference between free/reduced-price lunch status students in the control versus experimental class, nor for the full-price lunch status students in the control versus experimental class.

Findings for Research Questions 2, 3, and 4

Research Question 2 asked, "What are students' perceptions of the inverted instructional model of delivery?" Research Question 3 asked, "What are the parents' perceptions of the inverted instructional model of delivery?" Research Question 4 asked, "What are the instructor's perceptions of the inverted instructional model of delivery?" For these research questions, the independent variable is the format of lecture delivery; the dependent variables are the perceptions of the students, parents, and instructor.

Data for these questions were gathered through student and parent surveys, a student focus group, and an instructor reflective journal. When analyzing the data, I sorted the individual questions into six common themes: accountability, accessibility, technical, comprehension, pedagogy, and preference for format. Data are reported by theme, with questions from the surveys, focus group, and reflective journal all being reported under each theme.

Accountability. Accountability was a theme that emerged from each qualitative source of data. Accountability refers to whether or not the students accept responsibility for watching the videos on their own as part of their homework assignment. This theme included questions about how often the students watched the videos as assigned, and it also included analysis of the reasons why they might not have watched the videos. It also refers to ways that I can ensure that the students watched the videos. In the student survey, Question 7 and Question 8 addressed this theme. Question 7 asked, "When a video was assigned for homework, approximately what percent of the time did you actually view the video?" Figure 10 depicts how often students said they watched the videos, on average.

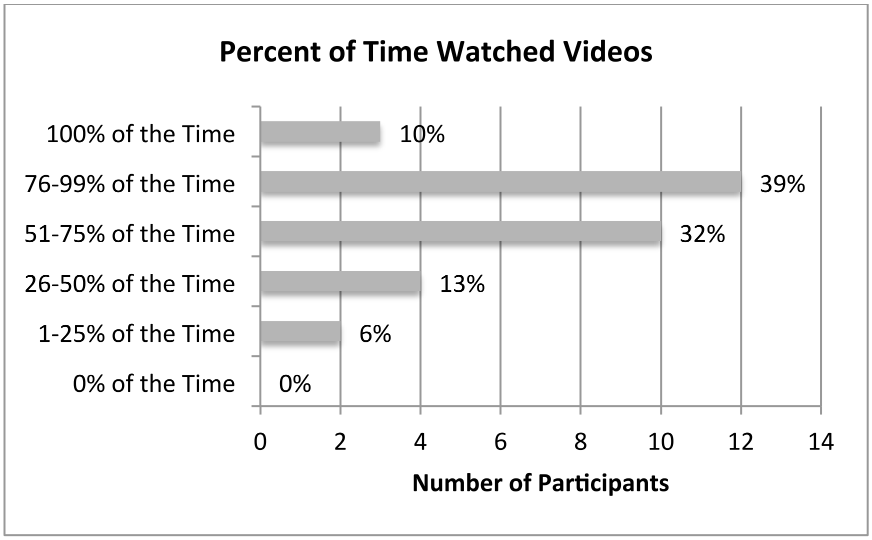

Figure 10. Percent of Time Watched Videos.

Question 8 asked, "On average, how many times did you watch each assigned video?" Figure 11 shows responses broken down by the average number of times the videos were viewed.

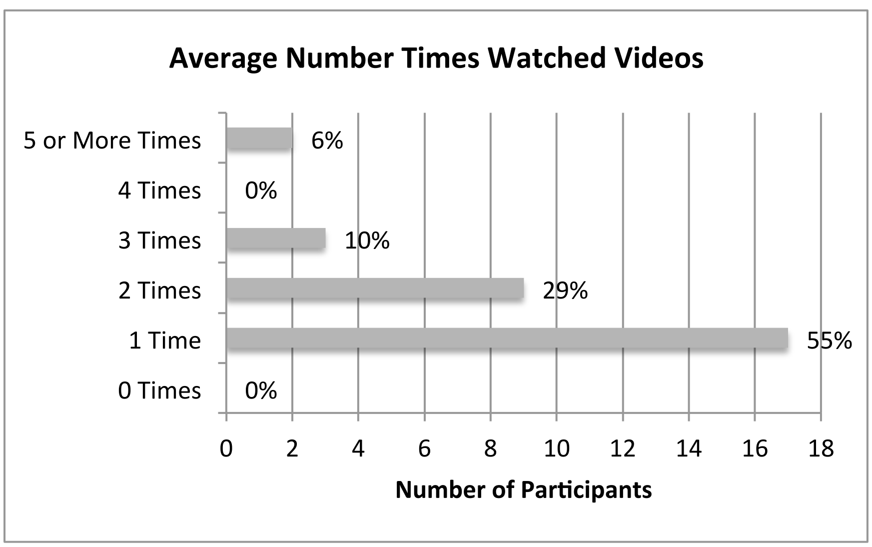

Figure 11. Average Number Times Watched Videos.

In the student focus group, in response to the prompt, "Based on what you have experienced so far in this course, what advice would you give another student who wants to take the flipped course next year," five of 12 students said that watching the videos was the advice they would give.

Another focus group question asked, "Do you think ninth graders have the self-discipline it takes to do the work at home on their own?" Out of six responses, two students said no, and three others said it depended on what activities they had planned for the evening. Participant 7 said, "Well, um, it's like a 50/50 chance because, like, you can have practice after school or something and then when you're done with practice all you wanna do is go home and rest."

Overall, data indicated that accountability was a problem for ninth-grade students as is evidenced by the fact that only 10% of students watched the videos 100% of the time as assigned. Students did realize, however, that self-discipline (accountability) was a problem for some ninth graders and that they must treat the video assignments like they would any other homework and make sure to view them.

Parents also addressed the theme of accountability. Question 2 in the parent survey asked, "To your knowledge, did your child watch the videos as assigned?" Parent answers are presented in Figure 12. Eighty-six percent of parents responded that their child did watch the videos as assigned.

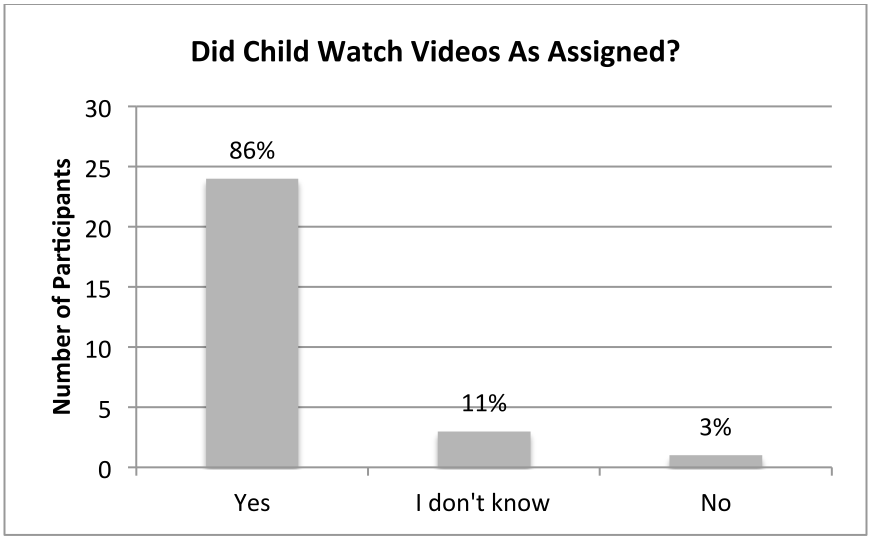

Figure 12. Did Child Watch Videos as Assigned?

Question 4 asked, “Did your child ever talk about their flipped science class at home? If yes, please explain what they said.” Parents’ responses varied and are depicted in Figure 13. Seventy-five percent of parents indicated that the student had told them about the video assignments.

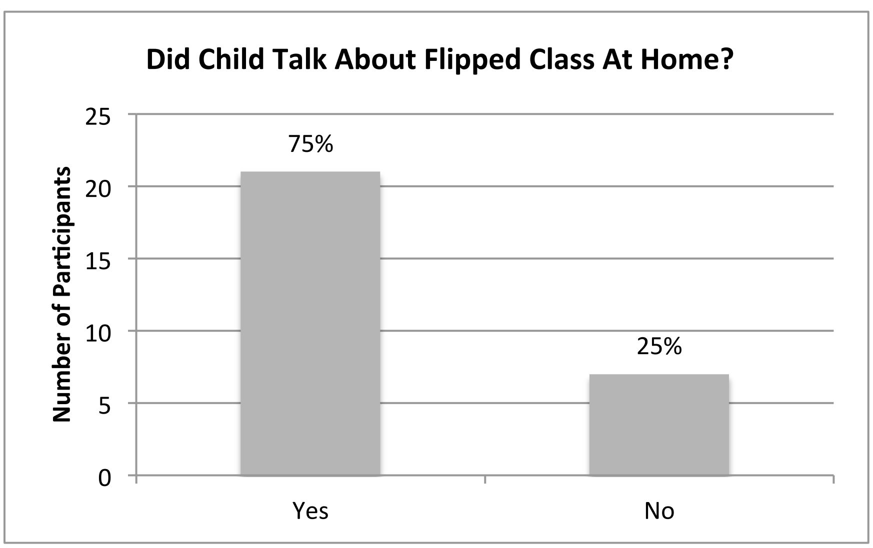

Figure 13. Did Child Talk About Flipped Class at Home?

Question 6 asked, “Suppose a friend of yours has a child going into ninth grade next year, and will be taking the flipped science class. What advice do you have for them?" Answers regarding accountability emerged. Forty-three percent of parents said their advice would be for the students to always watch the videos. Parent 3 said, "I would tell them to be sure their child watches the videos, asked questions when needed, and works hard in class." Parent 12 suggested, "I would advise them to pay close attention to the videos, and ensure that they have multiple methods of accessing the Internet. I would advise them to write down any questions they may have during the video." Parent 14 said, "Watch the videos with your child."

Based on the above data, the majority of parents emphasized the fact that accountability was an issue, and that students should watch the videos as assigned and, in addition, take notes so questions could be asked later in class.

Accountability was also an issue as documented in my reflective journal. In my journal, at the end of Unit 1, I reflected,

> When students were assigned a video, the next day when I asked if anyone had any questions, very rarely did a student ask a question. However, as we progressed into the lesson, I would have them say that they do not understand something in the video.

I also wrote,

> In spite of the fact that students said they viewed the videos, they still would ask basic questions that were covered in the video, so I am not sure whether they are really watching the videos or not understanding and therefore asking questions. An example of this is the use of video to introduce laboratory activities. I told students that unless they asked questions, I would assume they understood the laboratory instructions given in the video, and they would move directly into the

> activity. However, as they began the activity, they sometimes seemed confused as to what to do, even though it had been covered in the video.

At the very end of the study, when I was considering Question 3 which asked, "What aspects of my teaching did I feel needed improvement," I reflected,

> I did not feel like there was enough accountability for watching the videos. I feel there needs to be a way to hold the students accountable, such as having them login with a unique identifier, or take an online quiz, to ensure that they are watching the videos. I would love to take this one step farther and even have a way of viewing usage statistics for each individual student. The problem is that some of my students had to put the videos on their flash drive due to no internet access, so there is no way of tracking them or having them respond online.

Overall, my journal states that students said they were watching the videos, but were either not watching them all or not devoting full attention to the understanding of the videos. In my journal, I reflect that perhaps more questions should be asked about the videos at the beginning of the next class to clear up any misunderstandings. In addition, journal entries suggest a need to be able to track individual student usage of the videos so students could be held accountable for doing their video homework in preparation for the next day's activities.

Accessibility. Another theme that emerged in all qualitative sources of data was that of accessibility to the videos. Accessibility refers to whether or not the student has reliable access to the technology needed to watch the videos, or is able to depend on the functionality of the technology in all circumstances. Data included in this theme includes what type(s) of technology the student preferred and utilized, how often they watched the videos, and when they watched the videos.

In the student survey, Question 5 asked, “When viewing the assigned homework videos, what form(s) of technology did you use? Check all that apply.” Figure 14 shows their answers broken down by type of technology used. Students could choose more than one answer, so each type of technology could add up to 100% total.

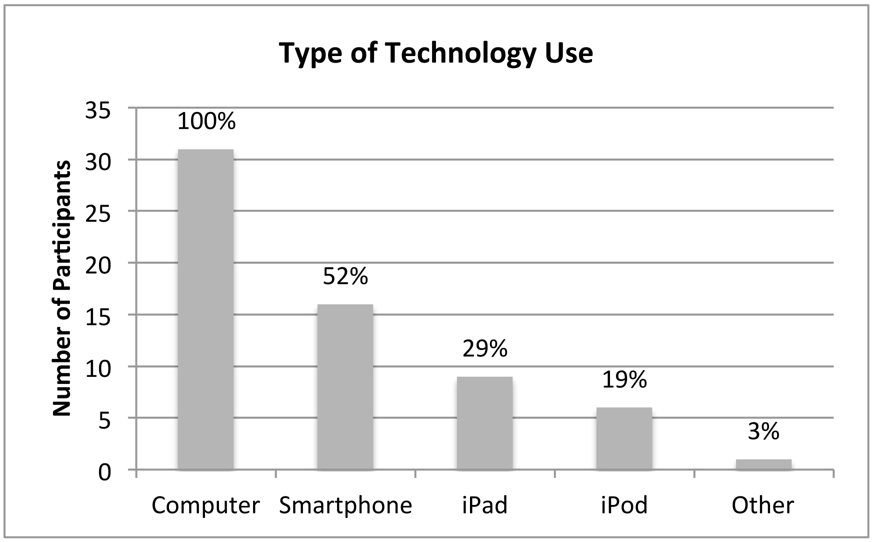

Figure 14. Type of Technology Use.

Question 9 elaborated and asked, “When did you actually watch the assigned videos?” Figure 15 shows student responses. Students could choose more than one answer since different videos could have been viewed at different times depending on their situation, so each answer could add up to 100% total.

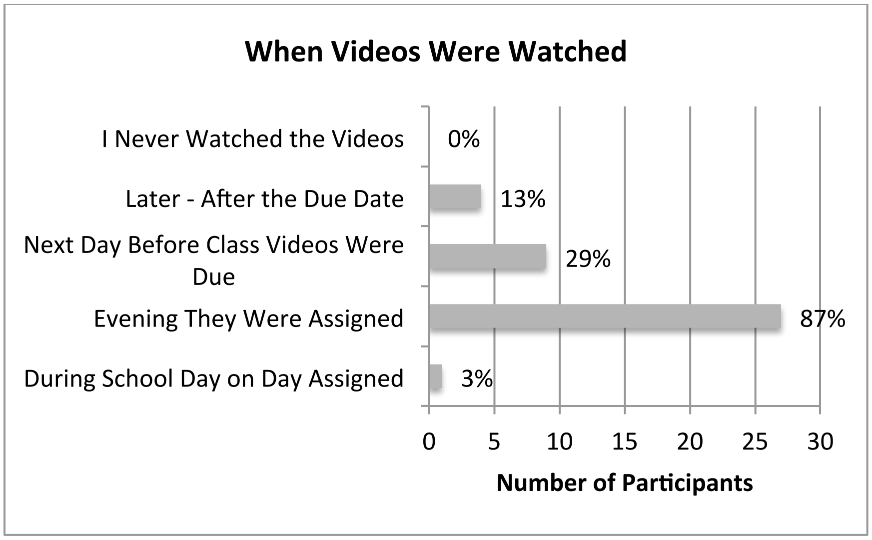

Figure 15. When Videos Were Watched.

Question 21 asked, “Which method of viewing the videos at home is your preferred medium for viewing?” Figure 16 shows student-preferred method of viewing videos.

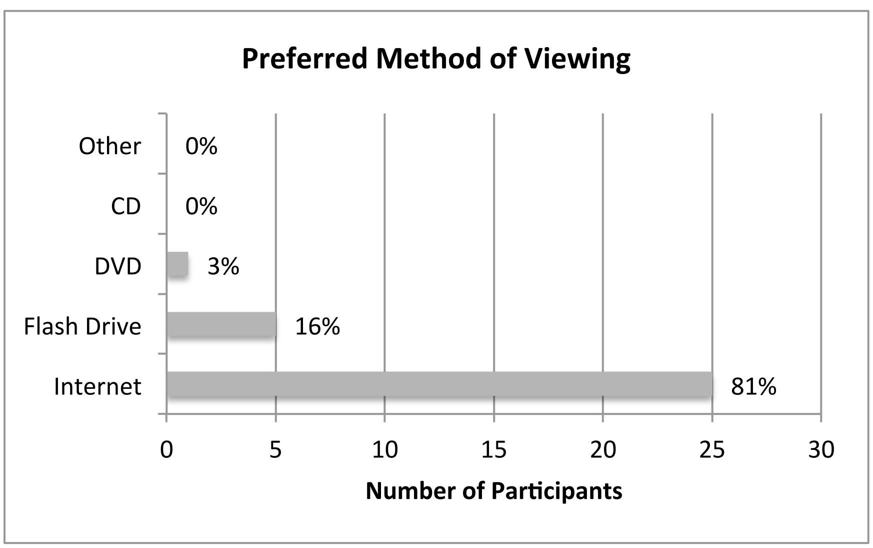

Figure 16. Preferred Method of Viewing.

Question 34 of the student survey asked, “Referring to Q33 (Suppose a friend came to you and asked whether you would recommend they take a traditional format science class or a flipped science class. What would you tell them?), explain WHY you answered the way you did," and 58% of responses noted accessibility issues. Of the responses noting accessibility, 66% of the students chose the flipped format class, while 34% chose the traditional format class. Participant 10 chose the flipped format and said, "With the video you get to watch it as many times as you want . . . but if the teacher teaches you can only hear it once." However, Participant 23 chose the traditional format, and justified it by saying, "Sometimes you don't have time or you forget to watch the videos."

In the student focus group, Question 7 asked, "Is there anything you feel I could have done differently to make this class better?" Two participants said that students being issued individual computers to use would be beneficial. Participant 11 said, "I think it would have been easier for me (getting computers) because I have a keyboarding class and I could have watched them right then but the way it was set up you couldn't do it (watch videos) at school because it was on YouTube."

Question 5 asked, "Do you feel that the flipped class format helps or harms you if you miss a class?" Out of the seven responses, two said it would harm them due to the amount of material to learn and the fact that they would be on their own to do homework at home instead of in the class like their classmates. Two said it would help them due to the fact that if they missed class, they could just watch the videos to catch up. Three said it would depend. Participant 30 said, "I think it depends on what we do that day. Like, if we just did labs in here, it would be kinda easy. But if you did worksheets, you'd have a lot to catch up on."

The parents addressed the issue of accessibility through Question 7 on their survey which asked, “Was access to technology (computer, smartphone, iPad, etc.) a problem for your child when trying to view the science videos? Explain.” Thirty-two percent of parents answered “yes” to this question. Parent 2 elaborated by saying, “There were a couple of times that the Internet wasn’t working and my child couldn’t pull up the videos on a smartphone, so we had to go to a relative’s house to view the videos.” Parent 3 said, “There was only a problem when the Internet was down.” Parent 5 said, “Sometimes the videos do not load or take a very long time to load.” Parent 21 said, “Her cell phone would not allow your page to download.” Parent 28 said, “I am a single mother of two and work 6 days a week. I cannot afford Internet and phone. Our computer was stolen by his father last year.”

From my reflective journal, I also addressed the issue of accessibility. I checked the website at the end of the study period for the total times each video was watched, and calculated the average for each category of video. Results of this analysis are presented in Table 18.

Table 18

Average Number of Times Videos Viewed

Average Number Times Viewed	Lecture Videos	Homework Review Videos	Pre-lab Videos	Test Review Videos	Extra Help Videos
N = 31	39	57	67	54	25

Even though at the end of the study the averages are relatively high, in my reflective journal, specifically for the lecture videos Magnetism and Thermal Energy, immediately after the videos were due, the total viewings were lower than the actual number of 31 students in the class, which indicated that not all students watched the videos as assigned. At the end of the study, I wrote:

> If I had it to do over, I would do things differently due to accessibility issues. One student in particular who lived with a single parent said that he could access the videos via flash drive, and even downloaded them every time he needed to from my computer. However, I suspect that he wasn't able to watch the videos because his One-Minute Response grades were not good. It is because of students like him that I would do things differently next time. I thought by offering before or after school access to my computers it would allow those who do not have a computer or smartphone to watch. But this did not happen. Those students who do not have access to computers at home were the very ones who also depended on the bus for a ride to and from school, and so before and after school were not a feasible option for them. This puts these types of students at an unfair advantage.

I also reflected at the end of the study that

> I'm still feeling like the students are not taking the video watching seriously as they should. I am rather disappointed in test grades, and my analysis of this is that they are not watching their homework review videos as they should, many are not watching the lecture videos, as is evidenced by the one-minute responses.

And one of my last reflections stated,

> The only way to ensure complete equity of access is for the school to provide to each student the same technology platform to use in the course. Then I could have the exact same expectations for all students in the class.

Another reflection discussed the YouTube access problem mentioned by the students.

> Some students commented to me that because the videos were actually stored on YouTube with links on my website, they had problems accessing the videos from school since YouTube is blocked. I acknowledge that this was a problem, but the web hosting service I used, Webs.com, for some reason would not let me store the videos on the website at the time, so I had no option.

In summary, the majority of students said they watched the videos via computer and the Internet the evening they were assigned. Students reported liking the videos because they could be watched multiple times as needed. Some students felt that computers should have been issued to the class so that everyone had dependable technology. Parents shared the concern about accessibility, especially with respect to reliability of technology. Many reported that their child encountered technical issues occasionally that hindered them from watching the videos. My journal revealed that I felt accessibility was an issue. Accessibility issues noted in my journal included the school's practice of blocking YouTube and equity of access to reliable technology.

Technical. The third major theme to emerge throughout the qualitative data is that of the technology itself. The technical theme encompasses the actual technology students use to view the videos (computer, phone, etc.), the technical components of the videos themselves (length, quality of audio and video, etc.), and the amount of time students spent viewing video homework.

First, in the student survey, Question 4 asked the students to "rate your comfort level when using technology, such as computers, smartphones, iPads, etc." Figure 17 shows their reported level of comfort with utilizing technology in general, with 100% of the respondents indicating that they had at least some comfort level with technology.

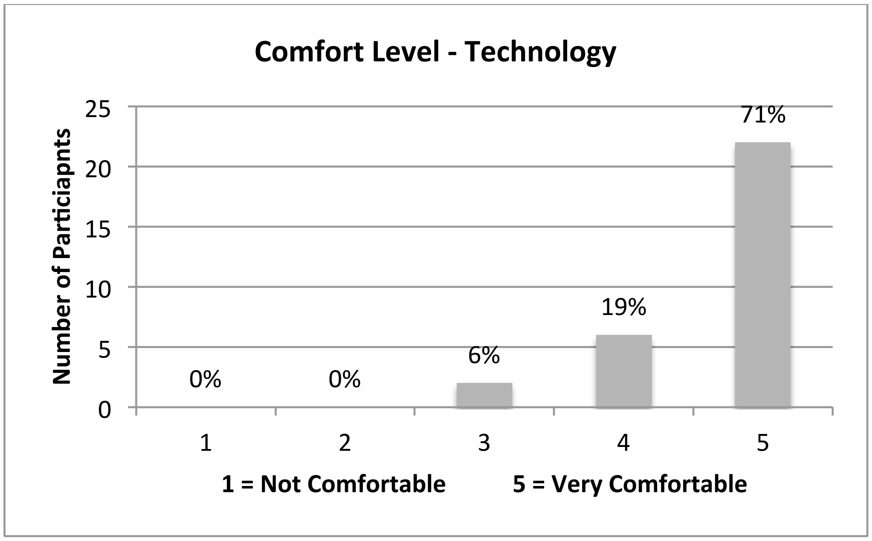

Figure 17. Comfort Level–Technology.

Question 11 asked, “Overall, how would you rate the length of the videos?” Figure 18 shows student satisfaction with the length of the videos (5-10 minutes). All agreed the videos were either just about right or too long.

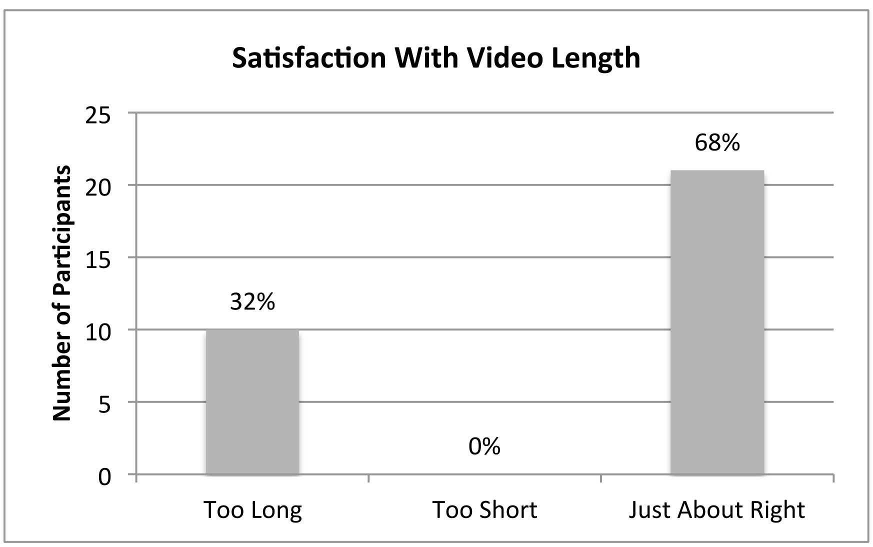

Figure 18. Satisfaction with Video Length.

Question 12 asked, “Overall, how would you rate the quality of the videos (audio and video)?" Figure 19 depicts what students thought about video quality. All students agreed that the videos were of average quality or better.

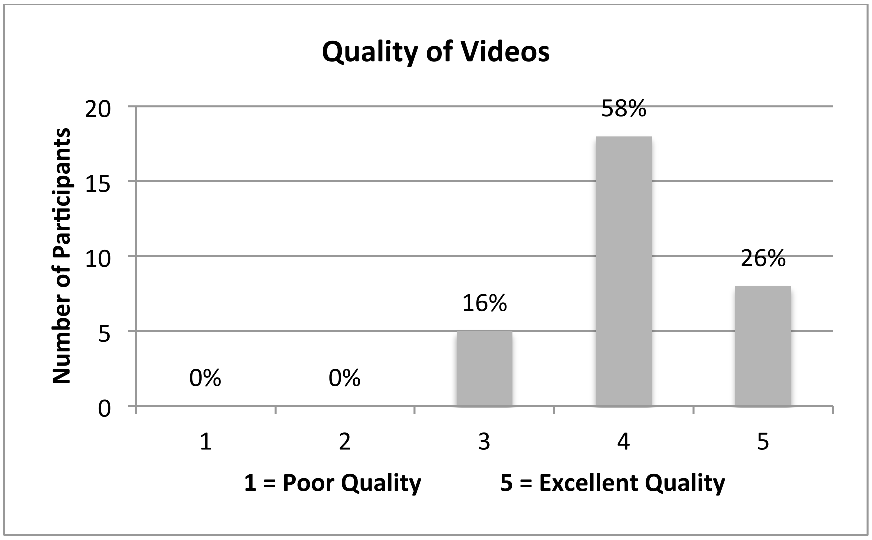

Figure 19. Quality of Videos.

Students elaborated on the technical issues theme in the focus group. One technical issue that kept surfacing was that of time. Participant 5 said, "I think it (flipped class) also helps because the homework can vary from like five minutes to like thirty minutes but then the video is just like ten minutes long." This student further elaborated that, "we had less homework." Participant 19 said, "I just like the fact that we could go home and watch the videos and it gave us more class time to do other stuff. That was enjoyable."

When asked about the animations in the videos, seven students responded. Of the seven, two said that the animations were distracting. Participant 30 said, "In the video, the little people, or things, moving around (my animations)–that was really distracting." However, five of the seven agreed that the animations helped them to understand the material. Participant 2 said, "I think the pictures help, because like, I specifically remember convection because you had the hot air balloon on it, and that really helped me, like radiation with the Sun." I then asked them "If you had your choice, would you have chosen a still picture or a moving picture?" The two students who responded chose the moving picture. Participant 25 said, "I would choose the moving because it kept me interested instead of trying to do something else."

I asked the students what I could have done to make the videos better, and eight students responded. Six of the eight said that I needed to explain concepts in more detail, and give more example problems. Participant 1 said, "If you had went into more depth it would have been good, even if the video was longer." Another student said that I should slow down the pace of the videos. And the last person said they would have liked to see me as I talked during the video.

Overall, students indicated that they were comfortable using technology and thought that the length of the videos was good. In addition, the majority of students were satisfied with the quality of the audio and video in the videos. Most students agreed that the picture and animations in the videos were beneficial to their comprehension of the subject.

My reflective journal also contained entries related to this theme.

> I felt that the actual videos were successful. New material lecture videos consisted of PowerPoints recorded on Camtasia 2 with me narrating the slides (Appendix C). The other videos (test review, pre-lab, homework review, and extra help) depicted the original handout the students received narrated by me (Appendix G) and were either done in Camtasia 2 or on the Wacom Bamboo Tablet.

Also, one entry describes me comparing the videos I made to Mayer's multimedia principles.

With regards to Mayer's multimedia principles, my presentations included both words and pictures (sometimes animations), animation and narration were presented simultaneously, the presentations were concise and to the point, and the words and pictures were presented simultaneously. The only area where I felt I didn't follow these principles was when I included narration and words with the graphics. However, my narration was more of an explanation of what was on the screen than me reading off of the screen, so I felt both were necessary.

In summary, most students felt comfortable using technology, and most agreed that the length and quality of the videos were good. Students indicated that they liked the fact that homework seemed to take less time. The majority of students felt that the pictures or animations in the videos helped them understand the material. My experience with production of the videos echoes the notion that they were successful with respect to length and quality, and were relatively easy to make.

Comprehension. The next theme that emerged was that of comprehension of the subject matter. Comprehension refers to the level of understanding students had of the material during and after watching the videos, and includes activities of students during the videos, levels of understanding of different types of videos, level of difficulty in class after viewing videos, level of preparedness of class after watching videos, and what strategies students felt were most effective in helping them learn the material.

First, in the student survey, Question 6 asked, "As you watched the videos, what else did you do?" This question addresses comprehension because doing other activities while watching videos could detract from student comprehension of material being presented. Figure 20 shows student responses. Students could choose more than one answer to this question, so each answer could add up to 100% total.

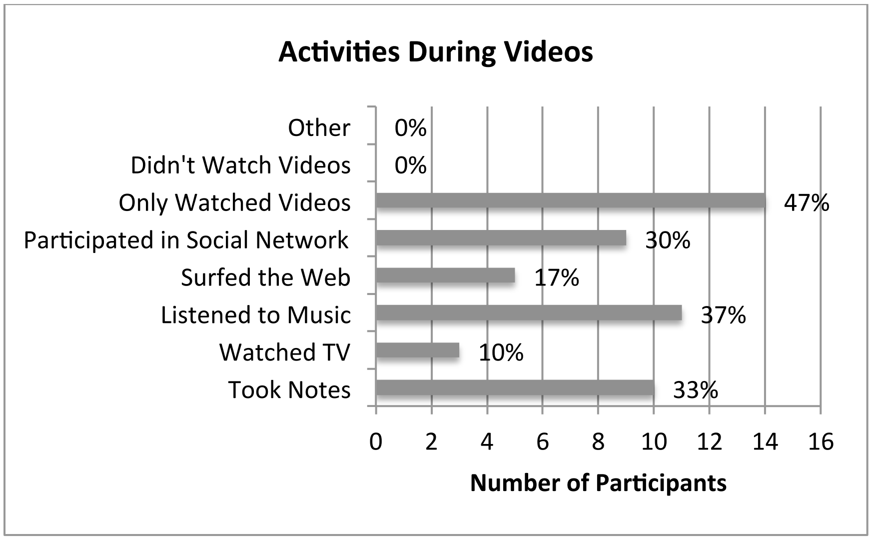

Figure 20. Activities during Videos.

In the student focus group, I asked students if they felt these other activities harmed their understanding of the material. Of the six respondents, three said yes. Participant 6 said, "No, that definitely does not help because most of the time I just focus on the other thing." Three students responded no. Participant 5 said, "I'm a multitaskual person so I can do many things at once."

Survey questions 13 through 16 ask students about their level of understanding after watching the different video types at home: chapter (new material) lecture, pre-lab, daily work review, and extra help.

Question 13 asked students to describe their level of understanding of information contained in videos for the textbook chapter lectures. Figure 21 shows responses, as rated on a scale from 1-5, with 1 being no understanding and 5 being complete understanding of material contained in new material lecture videos. This question asked about understanding the subject after watching the complete video, and shows that 94%

of students had at least a somewhat better understanding of the material after textbook chapter lecture videos.

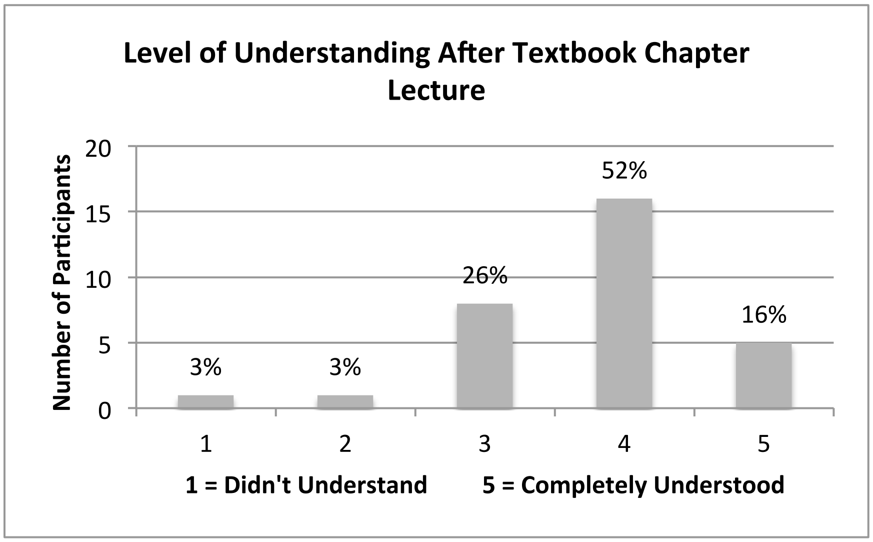

Figure 21. Level of Understanding after Textbook Chapter Lecture.

Question 14 asked students to describe their level of understanding of information contained in the videos for the pre-lab instruction, as rated on a scale of 1 to 5, with 1 being no understanding, and 5 being complete understanding of material contained in pre-lab instruction videos. Figure 22 indicates that 94% of students have an average or better level of understanding after viewing pre-lab videos.

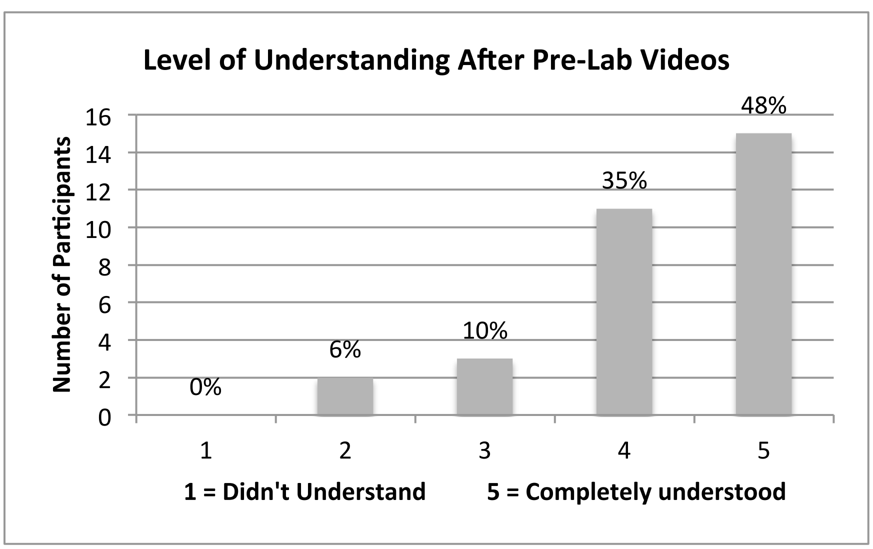

Figure 22. Level of Understanding after Pre-lab Videos.

Question 15 asked students to describe their level of understanding of information contained in videos for the homework review video instruction, as rated on a scale of 1 to 5, with 1 being no understanding, and 5 being complete understanding of material after viewing homework review videos. Figure 23 shows that 91% of students had an average or better level of understanding after viewing the daily work review videos.

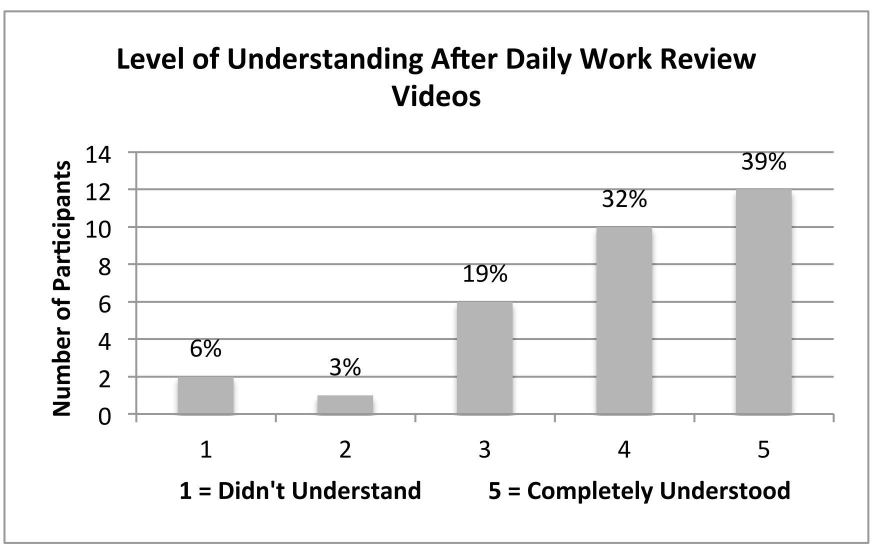

Figure 23. Level of Understanding after Daily Work Review Videos.

Question 16 asked students to describe their level of understanding of information contained in videos for the extra help instruction videos, as rated on a scale of 1 to 5, with 1 being no understanding, and 5 being complete understanding of material after viewing extra help videos. Figure 24 indicates that 83% of students had an average or better level of understanding after viewing the extra help videos.

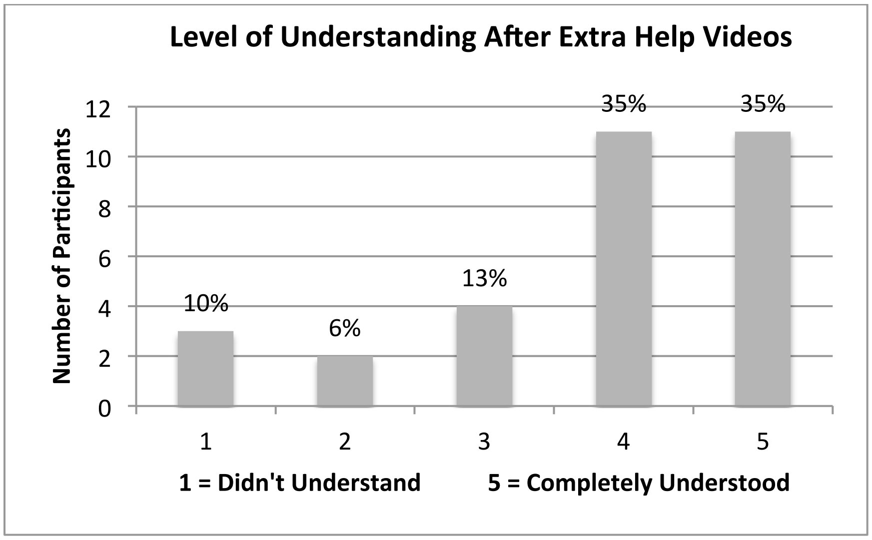

Figure 24. Level of Understanding after Extra Help Videos.

Question 23 asked students to rate the level of difficulty of the flipped class compared to a traditional class lecture delivery model, rated on a scale from 1 to 5, with 1 being not as difficult, and 5 being much more difficult. Figure 25 shows that 23% of students said the flipped class is more difficult and 22% of students said the traditional class is more difficult. Fifty-five percent of students were in the middle, saying neither is more difficult.

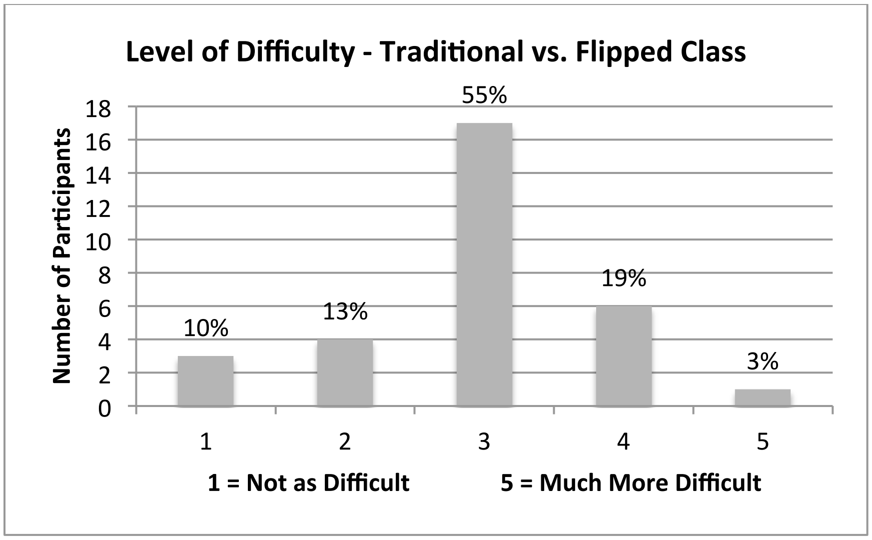

Figure 25. Level of Difficulty–Traditional vs. Flipped Class.

Question 4 sheds some light on why the students answered Question 23 as they did. It asked, “How challenging was this class to you? Explain.” Six students answered this question, and of the three that said the class was challenging to them, they agreed that the reason was because they needed more one-on-one teacher-student interaction in class.

Question 26 asked students, “As you watched the videos on the new material being presented, how difficult was it to understand the new material?” as rated on a scale from 1 to 5, with 1 being not difficult and 5 being very difficult. This question differs from Questions 13-16 in that it asked about understanding individual concepts while watching the videos. Figure 26 shows their responses–36% of students said it was not difficult, 45% said it was of average difficulty, and 20% said that it was difficult.

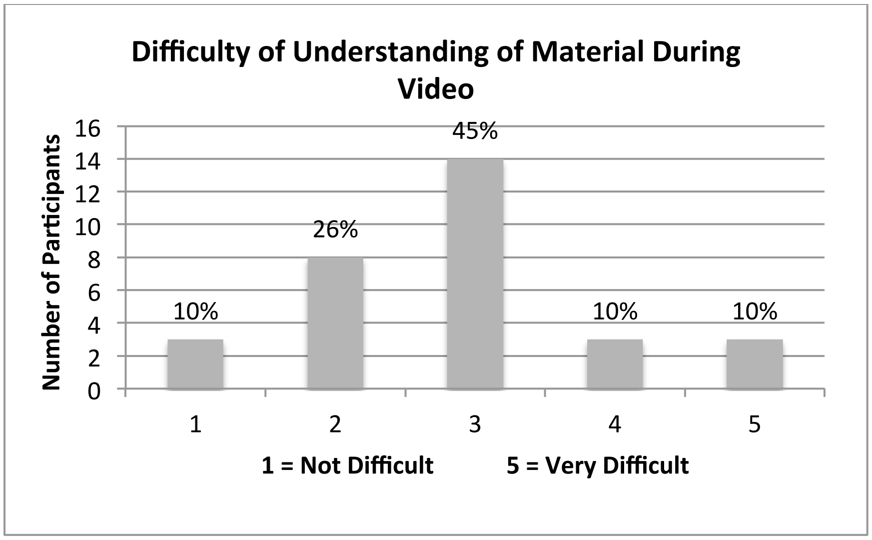

Figure 26. Difficulty of Understanding of Material during Video.

Question 27 asked, "How much did the discovery activity done before viewing the video assist you in your understanding of the video?" Figure 27 answers this question. Ninety percent of students said that the discovery activity made understanding the video at least somewhat easier, indicating that the pretraining effect occurred between Quadrant 1 and 2.

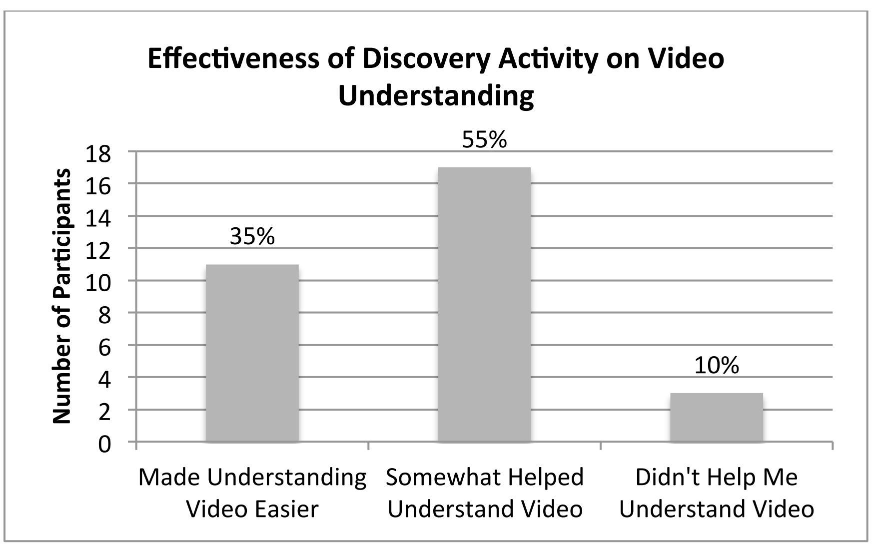

Figure 27. Effectiveness of Discovery Activity on Video Understanding.

Question 28 asked, "How well did the assigned videos you watched at home prepare you for the next day's class?" Figure 28 shows students' perceived levels of preparedness for class after watching videos at home. Eighty-seven percent of students said that watching the lecture videos made understanding class material the next day at least somewhat easier, indicating that the pretraining effect had again occurred between Quadrant 2 and Quadrant 3.

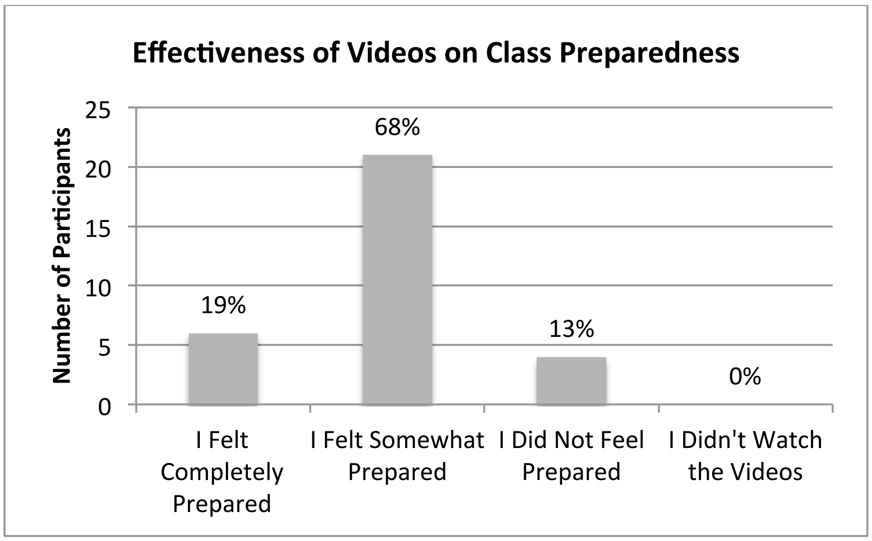

Figure 28. Effectiveness of Videos on Class Preparedness.

Question 29 asked, "After you watched the videos that presented new material, how difficult was it to understand and perform the next day's activities?" as rated on a scale of 1 to 5, with 1 being not difficult and 5 being very difficult. Figure 29 shows 42% of students said that the next day's activities were not difficult after watching the homework videos, 29% were in the middle, and 29% said the next day's activities were more difficult after watching the videos without direct in-class instruction.

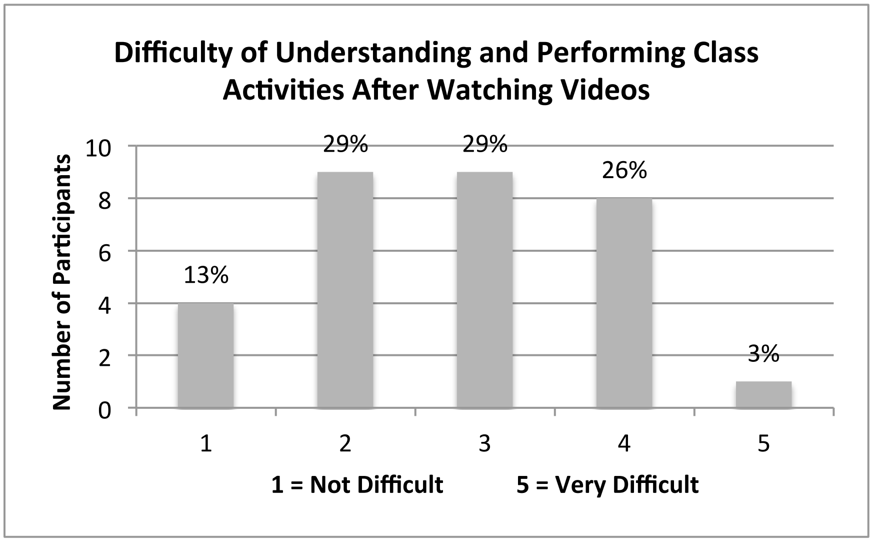

Figure 29. Difficulty of Understanding and Performing Class Activities after Watching Videos.

To summarize the survey results, 53% of students admitted to doing other activities while watching the videos. When rating level of understanding of material after watching the different types of videos, the majority of students said that their understanding of the material was better after viewing the textbook lecture videos, pre-lab videos, work review videos, and extra help videos. After viewing the videos, the majority of students said that performing classroom activities the next day was no different in level of difficulty than in-class instruction was. The majority of students also agreed that it was easier understanding the video after doing the Quadrant 1 discovery activity, and that it was easier performing the Quadrant 3 activity after viewing the video the night before, indicating that the pretraining effect was occurring twice in the learning cycle.

The student focus group also provided insight into the theme of comprehension. Question 4 asked the students, "How challenging was this class to you? Explain." There was no clear consensus of students on this question. Fifty percent of respondents felt it was harder than a traditional class. Participant 16 said, “I think it’s harder because with me, I have to have a one-on-one teacher-student, you know,” indicating that he/she needed one-on-one help with problems for full understanding. However, 50% of respondents felt it was easier. Participant 11 elaborated, “I think for me it was easier because I don’t like listening to other people’s questions because it confuses me.”

Some responses from various questions indicated there should be more follow-up explanation of the videos. Participant 30 said, “I think we should have a class discussion at the beginning of class and everybody talk about it (the lecture video).” Participant 14 added, “Do, like, more than one practice problem (in the video).” Participant 5 commented, “I think that everything could have, like, been explained more into detail. Cause they were explained on there, but at the end of it (video) I still had a little bit of questions on a couple of things cause they weren’t explained all the way through.” Participant 1 said, “Like, when you had the PowerPoints on there and stuff, how you summarized it up pretty much, like she said if you had went into more depth it would have been good, even if the video was longer.”

In the student survey, Question 24 asked the students, “Which type of classwork did you find to be the MOST effective in helping you learn the material in the flipped science class?” Figure 30 shows what in-class activities students felt most helped them learn the material the best. Fifty-two percent responded that small group work was the most effective for them.

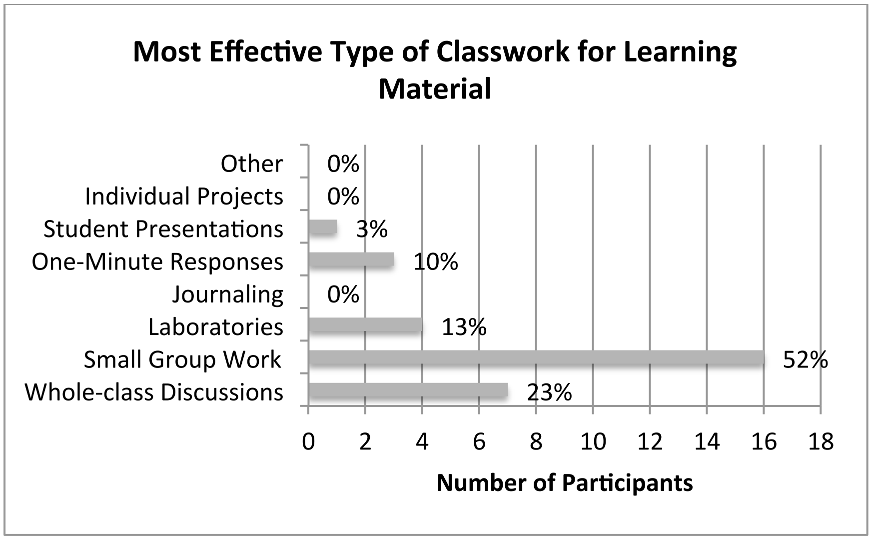

Figure 30. Most Effective Type of Classwork for Learning Material.

In the focus group session, I followed up on this question by asking, "Why is small group work most effective in helping you learn material?" Out of the 12 responses for this question, nine said they felt working with others and getting help from their friends was the most effective, one student said they learned better by doing, and two said that it made learning more fun. Participant 27 stated, "Like, if I don't understand something, then usually (she) understands it, so she explains it to me, and I'll explain to her, so we both understand it and you don't have to ask questions."

Overall, for the theme of comprehension, the majority of students indicated that they had a better understanding of the material after each type of video: new material lecture, pre-lab, work review, and extra help videos. Students also indicated that the discovery activity from Quadrant 1 aided them in understanding the assigned new material video, and 87% felt that they were prepared for the next day's class after watching the videos. The majority of students admitted that small group work in class helped them learn and understand the material more than other activities done in class.

However, 65% of students admitted they had difficulty at some level understanding the new material videos, and 77% of the students said they thought the flipped lecture format was more difficult than the traditional lecture format. A few students offered suggestions for improvement of the videos that would aid in their understanding by saying they would like to see more explanation in the videos and/or in class after the videos.

In the parent survey, the theme of comprehension also emerged. Parent 2 said, "Sometimes, my child thinks that a little more explanation would be beneficial." Parent 4 said, "My child talked about it (the class) being difficult for her due to her learning style."

My reflective journal also mentions the theme of comprehension. One entry, referring to an activity where students had to design, on paper, a Rube Goldberg machine using their knowledge of potential and kinetic energy and energy conversions, said,

> Students were asked to view the Energy lecture video, and when they came to class the next day, did great on the One-Minute Response, indicating they had watched the video. However, as I looked at some of the posters, I realized that students still weren't totally grasping the concept of energy conversions because they were misrepresenting some conversions.

A separate entry, referring to another project where students had to create a children's book with a given theme that correctly relays the concepts of heat conduction, convection, and radiation, revealed the same thing.

> I noticed that when I was grading the books, a few had totally missed the concept of convection. Most got conduction and radiation correct, but some obviously did not understand the concept of convection despite having viewed the video. I don't think they are asking enough questions after viewing the videos.

At the end of my reflections, I wrote, "As I look back, one thing I might do differently next time is to create a guided note-taking sheet for students to fill out as they watch the videos. This might help them concentrate on the video and think about what they are writing."

Overall, parents felt that their child should ask more questions about the video material, and this coincided with my journal entries on the same subject. My journal entries indicate that students would benefit from asking more questions, and perhaps I should encourage guided note taking during the videos to keep the students focused.

Pedagogy. The next theme to emerge from data analysis was that of pedagogy. The theme of pedagogy is defined as the method(s) of teaching and how effective they are. This theme encompasses what the students used the videos for, the methods of instruction students preferred to receive, and the amount of time students spent interacting with the instructor.

In the student survey, a few questions fell into this category. Question 10 asked, "For what purpose(s) did you watch the videos? Check all that apply." Figure 31 depicts student answers. Since students could check more than one response, each answer could add up to 100%. The majority of students used the videos for all three reasons.

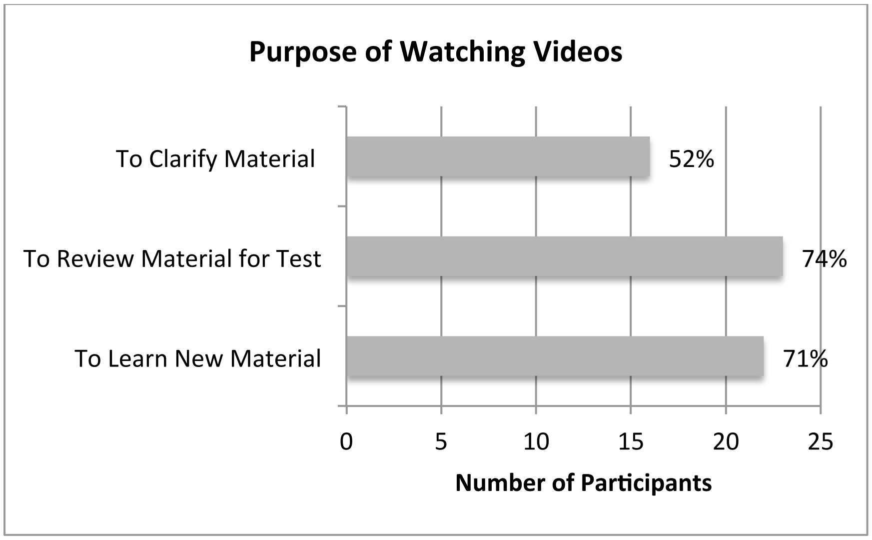

Figure 31. Purpose of Watching Videos.

Questions 17 through 20 asked, "For each of the following types of instruction, choose the circle that BEST describes whether you prefer in-class instruction or at-home video instruction." Figures 33-36 present their answers.

Question 17 asked whether students prefer in-class or at-home video instruction for new material (textbook) lecture. Figure 32 shows that 65% of students prefer in-class lecture for new material.

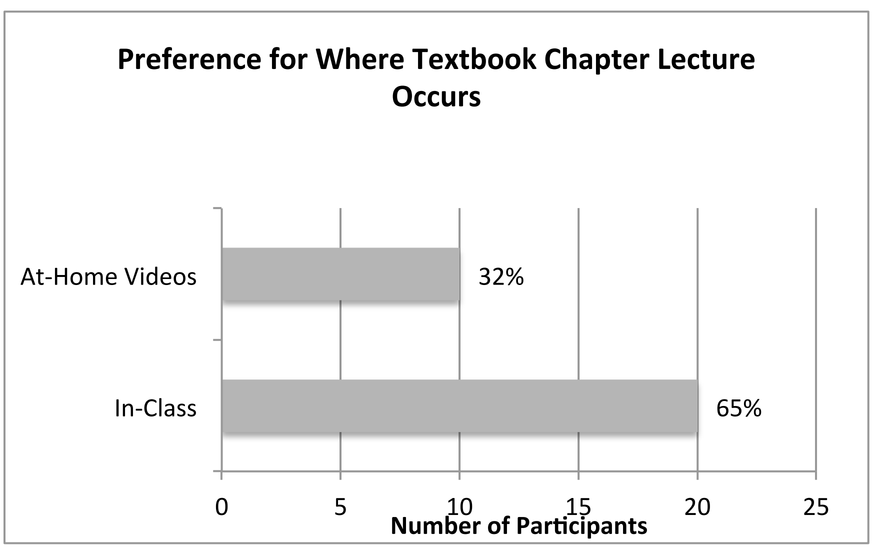

Figure 32. Preference for Where Textbook Chapter Lecture Occurs.

Question 18 asked whether students prefer in-class or at-home instruction for their pre-lab procedure instruction. Figure 33 shows that approximately one-half of the students prefer at-home video instruction and half prefer in-class instruction for pre-lab instructions.

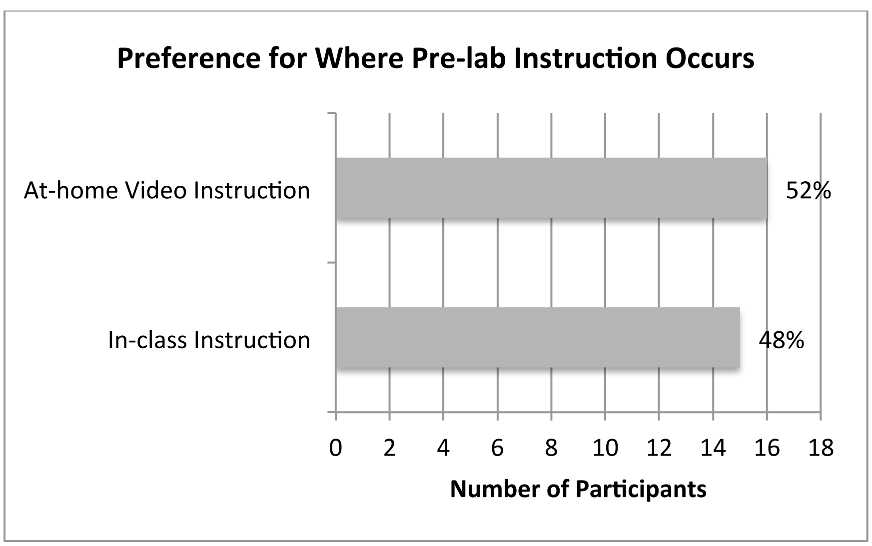

Figure 33. Preference for Where Pre-lab Instruction Occurs.

Question 19 asked whether students prefer in-class or at-home instruction for classwork review. Figure 34 indicates that 61% of students prefer in-class instruction for classwork review.

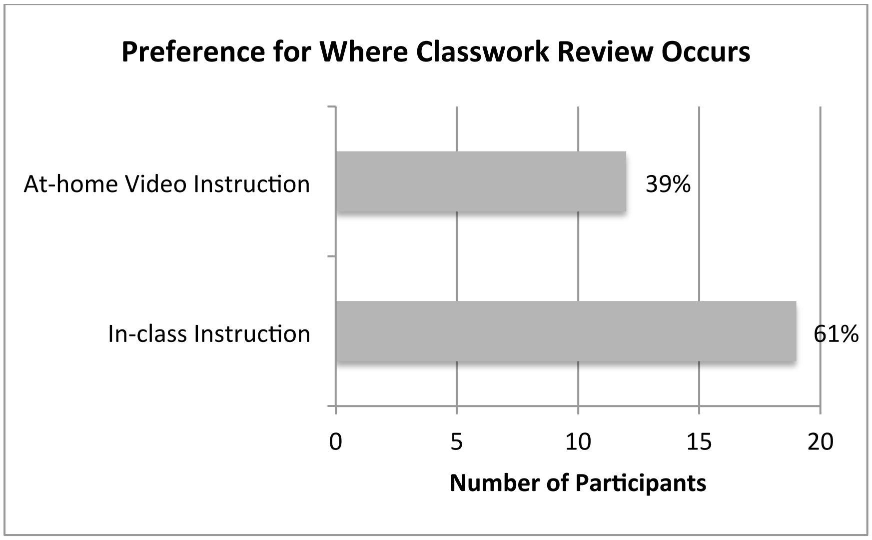

Figure 34. Preference for Where Classwork Review Occurs.

Question 20 asked whether students prefer in-class or at-home instruction for any type of extra help they need. Figure 35 shows their preference. Again, 55% of students said they prefer in-class instruction when receiving extra help.

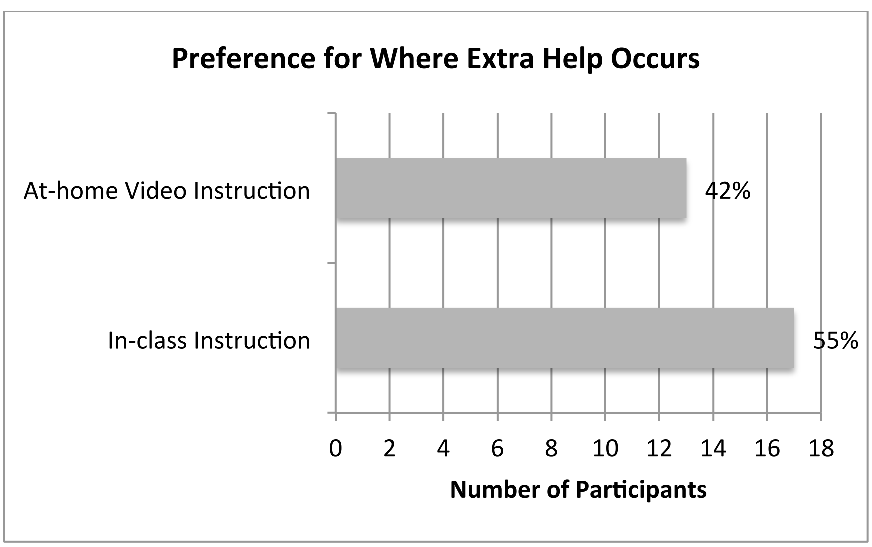

Figure 35. Preference for Where Extra Help Occurs.

Based on the data shown in Figures 33-36, it is clear that students preferred in-class instruction for all but pre-lab instruction. However, even though most students preferred at-home instruction for pre-lab activities, it was by a narrow margin.

Question 22 asked about whether students believed they spent more time on traditional homework versus video homework. Figure 36 indicates that 42% of students said they would spend more time on traditional homework and 35% on video homework.

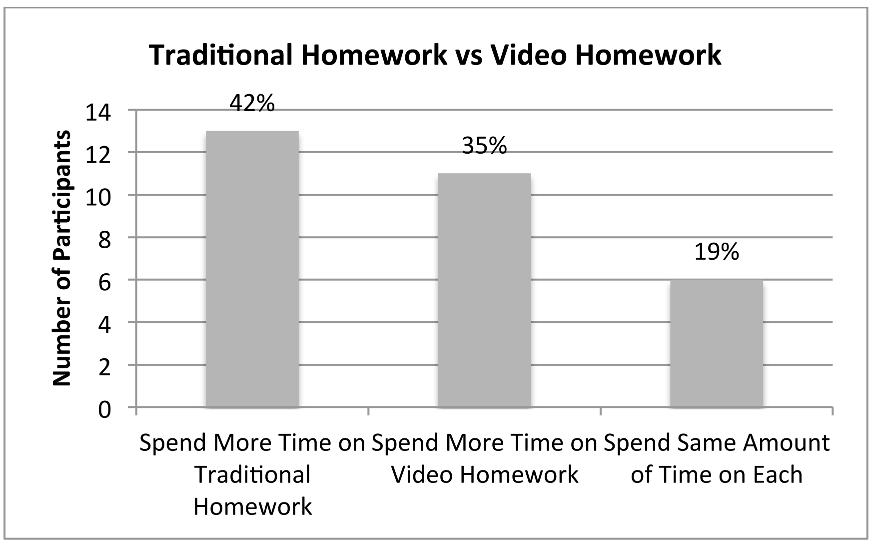

Figure 36. Traditional Homework vs. Video Homework.

Question 25 asked, “Compared to a traditional science class, how would you rate the amount of time spent individually interacting with the teacher?” Figure 37 indicates that the majority of students, 42%, believed they spent less time interacting with the teacher in the flipped class format.

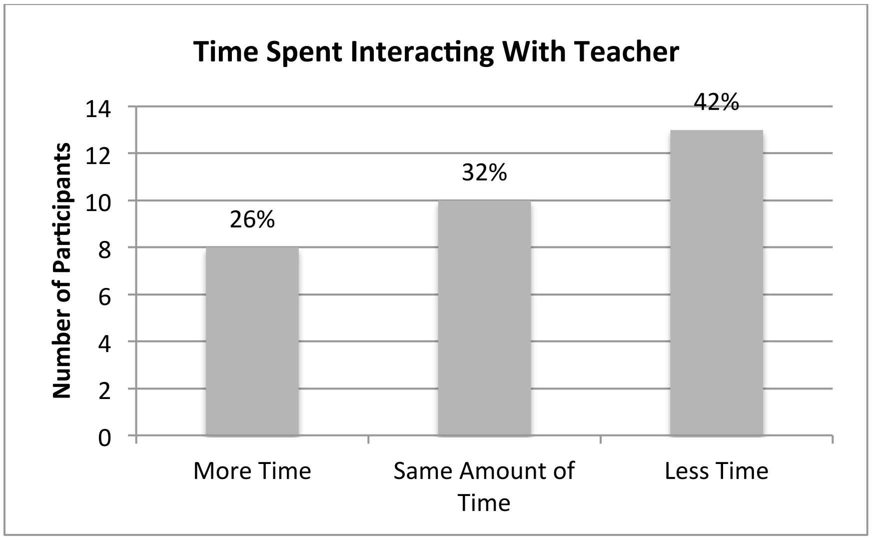

Figure 37. Time Spent Interacting with Teacher.

Questions 34-36 on the student survey revealed some comments related to the theme of pedagogy. When asked what they liked most about the flipped class, 59% said the in-class hands-on activities, 28% said having the video resources, and 14% said not having traditional homework.

To summarize, the majority of students said they used the videos not only to learn new material, but also to review for tests. In addition, most students would prefer to receive the majority of their instruction in class, with the possible exception of pre-lab instruction. The majority of students felt that they spent less time interacting with the teacher, which is contradictory to one of the reasons for flipping the class to begin with: to free up more class time for teacher-student interaction. Based on data collected in the student and parent focus groups, the reason why students believed they had less teacher-student interaction became clearer. Students revealed that they tended to rely on themselves more in class because they had watched the video the night before, and since they worked in small groups much of the time, they tended to answer each other's questions. Question 12 in the focus group asked, “On your survey, a lot of you said that you spent less time individually interacting with the teacher in class. Why?” Exactly one-half of the students said less interaction was a good thing. Participant 27 elaborated by saying, “Like, if I don’t understand something, then usually (my friend) understands it, so she explains it to me, and I’ll explain to her, so we both understand it and you don’t have to ask any questions.” However, the other half of the class said less interaction was detrimental to their classroom performance. Participant 26 said, “I think that it was a bad thing (less interaction), because I learn by, like, seeing and listening to the teacher. Like seeing you explain it out.”

Parent surveys addressed the theme of pedagogy also through open-ended answers to questions. About one-half of the parents mentioned at some point that they were concerned that their child could not ask questions during the videos. About one-half of the parents also mentioned in at least one question that their child benefitted from the hands-on in-class work. Other individual responses were “My child really liked this approach because the teacher was available to help with homework at school,” “She enjoyed the fact that she had little written homework,” “She tells me about the projects she does in class,” and “I was told about the hands-on practice during class and that the class time seemed more relaxed.”

My reflective journal addressed this theme in a number of ways. One entry said, “I have been doing the 4MAT/flipped format since the beginning of school. So far, I have mixed feelings. At the beginning, the kids seemed excited about this, but now kind of consider it (watching videos at home) a burden.”

When thinking about how successful I felt overall, I reflected,

As the students worked in their groups in class, I noticed that they were engaged

> most of the time, and students were helping each other. However, I felt that some parts of the 4MAT learning cycle were hindering students from learning as much as they could have. For example, in Quadrant 4, sometimes the students would spend up to 3 days consolidating their knowledge into presentable format.

Although not part of my original journal, I noticed that in Question 24 of the student survey, only 3% of students said that the presentations in Quadrant 4 most helped them learn the material, which corroborates what I wrote in my journal.

My journal continued,

> I'm not feeling like this (Quadrant 4) is making that much difference at all. In fact, I would probably next year leave that quadrant out. I feel that this time could have been better used in either review or more meaningful hands-on activities. Also, I'm still feeling like the students aren't taking the video watching seriously as they should. I'm rather disappointed in test grades, and my analysis of this is that they are not watching their homework review videos as they should, and many are not watching the lecture videos, as is evidenced by the one-minute responses.

When reflecting on my successes, I wrote,

> There were two main aspects overall that I considered successful. First, the videos I felt were extremely successful: not so much as an initial lecture format, but for a resource that students could revisit as needed for review. Students mentioned over and over again that they loved having that resource, especially the night before tests. Second, I feel like the 4MAT learning cycle complemented the flipped class concept well. More inquiry was introduced into the lessons, which I believe had a positive effect on the students. At the beginning of the semester,

> students were uncomfortable with the inquiry method of learning, and required a lot of scaffolding. They were afraid to get the wrong answer or make mistakes. But as the semester progressed, I noticed a definite mind shift because the students began to dive right into the activities and depend on me less for help. They learned that they could make mistakes without fear of reprisal, and so were more apt to take risks. However, when students did not understand a concept, they would ask me to post an extra help video on the subject. Overall, I feel that my teaching was effective. The students seemed to love having the videos as a resource, and since this is the first time I have taught with the 4MAT method, I felt like the students learned and enjoyed science, many for the first time.

I also reflected that "I feel like the students are learning, even though the gains were not quite what I had hoped for." Table 19 depicts the average gain score for each group and each unit.

Table 19

Average Gain Scores

		Average Pretest Number Correct Questions/Total Questions	Average Posttest Number Correct Questions/Total Questions	Average Gain Score
Unit 1	Control Class	12.16/28	19.68/28	7.52
	Experimental Class	13.90/28	20.84/28	6.94
Unit 2	Control Class	9.92/26	14.84/26	4.92
	Experimental Class	10.48/26	16.06/26	5.58

When reflecting on things I felt needed improvement, I wrote,

> Students told me that they felt they needed more review of each lesson at the end of the lesson. This indicated to me that perhaps the way I was teaching in Quadrant 4 was not adequate, because this is where the students were to consolidate and present what they had learned to the class. And last, I noticed that students continually struggled with the math in the lessons. I feel like I had less time to spend with them doing math problems this year than I have in the past, and it hurt them. Again, I believe this goes back to the Quadrant 4 issue I mentioned– that a disproportionate amount of time was spent in this quadrant, with little gain. Perhaps the way I was teaching in Quadrant 4 was not adequate. Maybe I need to figure out something else to do here that allows the students to review the material in a way that more appropriately meets their needs. One thought I had is that maybe, instead of just having the students make a synthesized presentation to the class, to have the class be more actively involved by actually critiquing the presentation as a whole group. This would identify and correct any misunderstandings for the whole class.

When reflecting on conditions that were important for student learning, I wrote,

> I believe that flipping the lecture part of class to the outside definitely is an advantage for the students–it enabled me to commit more time to inquiry activities, which I have not been able to do in the past. The inquiry activities were the most important condition for students learning to think critically, which allows learning to take place at a higher level of Bloom's taxonomy. However, before students were able to fully immerse themselves in inquiry and take chances and risk being wrong, they needed to know that it was acceptable to make mistakes,

> and that they wouldn't be ridiculed for them. And last, over and over students told me that working in small groups for the inquiry activities made learning fun, which in turn helped them relax and try new things without fear of failure.

I also reflected on what I believed to be unanticipated learning outcomes.

> The main unanticipated learning outcome was that the students became self-learners as compared to past classes I have taught. At the beginning of the semester, they struggled with taking responsibility for their own learning due to the fact that they had just graduated from middle school and had never had to do this. Grades were lower at the beginning of the semester. After numerous parent and student conferences, students came to realize that if they didn't take responsibility for watching the videos, getting extra help when needed, and participating equally in the inquiry activities, their grades would suffer. I became encouraged, however, when about three or four lessons into the first unit, students began asking me to create extra help videos on difficult subjects. I also saw some attitudes toward science change as the semester progressed. The students remarked on how they loved the inquiry activities, and many said that they enjoyed science for the first time.

In summary, the average gain scores for students were not what I expected, and I felt that perhaps part of the problem was that an inordinate amount of time was spent in Quadrant 4, when that time could have been better used in other instructional activities that would have a greater impact on scores. Overall, journal entries indicate the videos were a good resource for the students to use as a supplement to in-class learning, and the 4MAT learning cycle method of teaching complemented the flipped classroom well. One of the positive unintended outcomes was that students seemed to be learning how to do inquiry more by themselves instead of relying on me for constant help.

Preference. The last theme that emerged in all data was that of overall preference for lecture format. In the student survey, Question 33 asked, “Suppose a friend came to you and asked whether you would recommend they take a traditional format science class or a flipped science class. What would you tell them?” Figure 38 shows that a slight majority, 58%, would recommend the flipped class format to their friends.

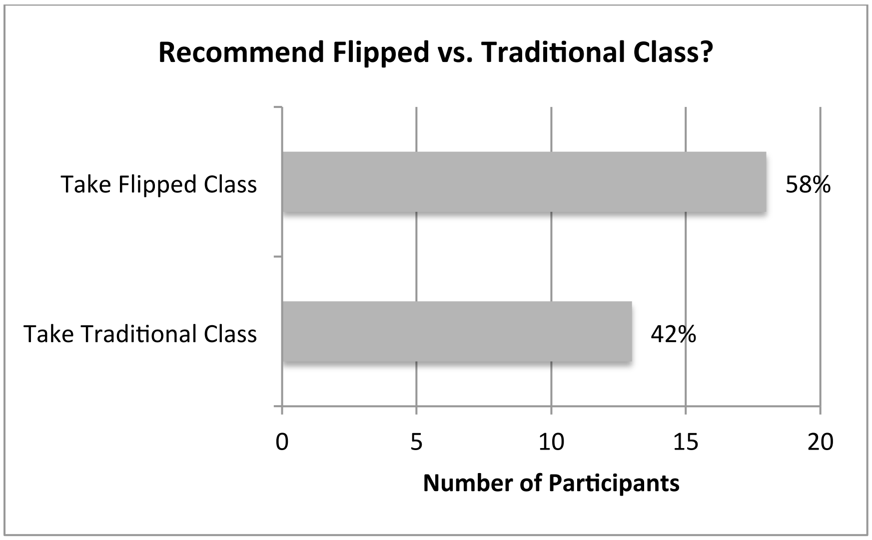

Figure 38. Recommend Flipped vs. Traditional Class?

Reasons students gave for their preferences have been detailed within the other themes, both for the student survey and for the student focus group.

On the parent survey, Question 3 asked, “Given a choice, would you rather your child be in a traditional science class, or a flipped science class?” Figure 39 shows how they answered. Fifty-four percent of parents said they prefer the flipped class format, which is similar to what the students said.

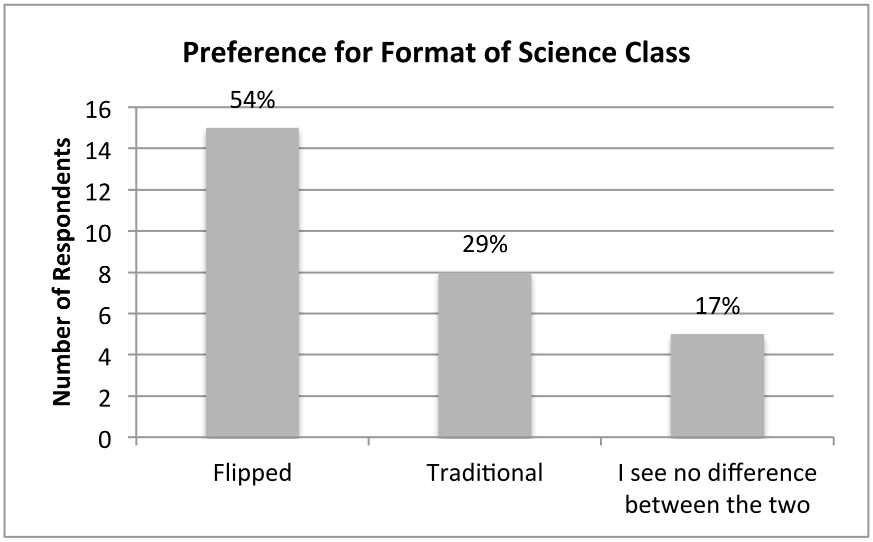
Preference for Format of Science Class
Number of Respondents
16
14
12
10
8
6
4
2
0
54%
29%
17%
Flipped
Traditional
I see no difference between the two

Figure 39. Preference for Format of Science Class.

Thirty-nine percent of parents indicated that they have seen a change in their child's attitude toward science since the beginning of their ninth-grade year, and in the focus group, students attributed this change to the fact that they had less homework, more hands-on activities being done in class, the ability to work in small groups in class, and the ability to do homework in class.

My reflective journal documented my perceptions as to which method I believe to be best. One of the final entries stated,

> In reflecting on the semester as a whole, I believe that, for my classrooms, the best approach would be a hybrid approach. That is, I believe that there are pros and cons to both methods. Given the budget conscious state of our district, obtaining computers for each child to use is not a feasible option at this time. In light of the fact that I felt that this would be the only way to level the playing field and ensure equal access for all students, I would not opt for a completely flipped class again unless it was a course that students could voluntarily choose to sign up for. I would, however, based on feedback from the students, continue to make

> videos and place them online as an extra resource for students to use as needed. I would also continue using the 4MAT method, however, I would modify Quadrant 4 to better meet the needs of my students. In an ideal world, however, I definitely would choose the flipped format over the traditional lecture format.

Based on this experience, journal entries indicate that I prefer the flipped format, assuming equal access to technology, and assuming that students would watch the videos, because this method allows more in-class inquiry-type activities crucial to successful learning in the science class, and provides video resources that can be stored and viewed as many times as needed.

Conclusion

These research findings, taken together, provide an overall picture of the inverted instructional delivery model of teaching. Table 20 shows the major findings for each of the identified themes.

Table 20

Major Findings for Quantitative Analysis

Theme	Major Findings
Achievement	• No difference in average gain between flipped vs. traditional class format • No difference in average gain due to gender or lunch status between control and experimental class • In one case, there was a statistically significant average gain between Caucasians and other races/ethnicities where Caucasians outperformed other races/ethnicities between control and experimental class. • No difference in average gain between females in control vs. experimental class • No difference in average gain between males in control vs. experimental class • No difference in average gain between Caucasians in control vs. experimental class • No difference in average gain between other races/ethnicities in control vs. experimental class • No difference in average gain between free/reduced-price lunch students in control vs. experimental class • No difference in average gain between full-price lunch students in control vs. experimental class

Table 21 shows the major findings for each of the six themes.

Table 21

Major Findings for Qualitative Analysis by Theme

Accountability	• Only 10% of students watched videos 100% of the time; the rest less. • 55% of students watched videos more than one time; the rest watched more. • Both parents and students would advise other students to watch the videos as assigned. • Must be a way to track which students watch the videos and their level of understanding.
Accessibility	• The preferred method of viewing the videos was via Internet on computer. • 87% of students watch the videos on the evening assigned • Parents and students both said reliability of the Internet is a concern for the flipped class format • Students and instructor recommend school issue computers with Internet access to each student for equal access
Technical	• 100% of students are somewhat to very comfortable with technology • 68% of students say 5-10 minute length of videos is just right • 100% of students say quality of videos was average or better • Majority of students believe that animations/pictures in the video aided them in learning material
Comprehension	• 53% of student admitted they did other activities while they watched the video • Majority of students said their level of understanding of the material overall was better after viewing all types of videos (new material, pre-lab, extra help, classwork review) • The majority of students believe that the flipped class is equal in difficulty to the traditional class • 65% of students said understanding the material during the video was difficult • 90% of students said the discovery activity before the video aided them in understanding the video • 87% of students report that the video prepared them for the next day's class • 42% of students said the video aided them in doing the next day's activities, while 29% said it do not help • 50% of students felt the flipped class was more difficult than a traditional class • 52% of students report that small group activities in class most aided them in learning material
Pedagogy	• The majority of students use videos to learn new material, clarify material, and to review for a test. • The majority of students prefer in-class lecture for new material lecture, classwork review, and for extra help. However, the majority of students prefer receiving pre-lab instruction outside of class. • 42% of students report interacting with the teacher less in the flipped class format than the traditional format because they are getting help from group members. • The majority of students say that small group inquiry activities in class help them learn material the best. • Only 3% of students said Quadrant 4 synthesis activity benefitted them the most; instructor concurred
Preference	• 58% of students would recommend the flipped class format versus traditional class format to their friends.

Statistical analysis of data gathered for Research Question 1 indicates that there is no statistically significant difference in achievement between the inverted lecture delivery model and the traditional lecture delivery model. When broken down into subgroups, it was revealed that there was no difference in average gain scores due to gender or lunch status between the two classes. However, for one of the two units, there was a statistically significant difference between Caucasians and other races/ethnicities grouped together (Asian, African American, Hispanic)–Caucasians had statistically significant higher average gain scores. However, since there were only five "Other" students in the experimental class and 3 "Other" students in the control class, these findings may or may not be representative of a larger sample of students.

In addition, there is no difference in gain score for experimental versus control males, or for experimental vs. control females. There is no difference in gain score for experimental versus control Caucasians, or for experimental versus control other races/ethnicities. And last, there is no difference in gain score for experimental versus control free/reduced lunch status students, or for experimental versus control full-price lunch status students.

Analysis of Research Questions 2, 3, and 4 data revealed six themes each has in common: accountability, accessibility, comprehension, technical, pedagogy, and preference. Qualitative analysis of these six themes provides a complete picture of student, parent, and instructor perceptions of the pros and cons of an inverted delivery lecture model.

Chapter 5: Discussion

The purpose of this action research study was to compare the effects of two models of instructional delivery within the 4MAT learning cycle, the traditional model of delivery and the inverted model of delivery on achievement gains in two Physical Science Honors classes as measured by statistical significance of scores on pre- and post-unit tests within a unit of study. In addition, students', parents', and instructor's perceptions about the inverted method of instruction were gathered and analyzed to see how successful they felt the model was and which strategies best enabled students to succeed.

The research questions to be answered in this study were:

1. Within the 4MAT model of inquiry-based instruction, what are the effects of an inverted instructional model of delivery on the performance of ninth-grade Physical Science Honors students as compared to traditionally delivered instruction?

2. What are students' perceptions of the inverted instructional model of delivery?

3. What are parents' perceptions of the inverted instructional model of delivery?

4. What are instructor's perceptions of the inverted instructional model of delivery?

To answer the research questions, various types of instruments were used so that data could be triangulated. Research Question 1 utilized a quantitative analysis of pre and posttest data, as well as quantitative analysis of disaggregated data based on gender, race/ethnicity, and lunch status. Research Question 2 utilized student online surveys and focus groups. Research Question 3 utilized parent online surveys. Research Question 4 utilized a reflective journal kept by the researcher.

This research was conducted to find out not only if the inverted classroom more positively affected student achievement in a science classroom but also to elicit perceptions of the students, parents, and instructor as to this method of lecture delivery. This research could be used to inform my own and other classroom teachers' practice about inverted instructional delivery in high school classrooms.

Findings

In addition to student achievement, six main themes emerged from triangulation of data: accountability, accessibility, technical, comprehension, pedagogy, and preference.

Achievement. Results from statistical analysis of pre and posttest data indicate that there is no difference in effectiveness between the control and experimental groups due to the treatment, or flipping of the classroom. There is also no difference in gain scores for experimental versus control class due to gender, race/ethnicity, or lunch status. Although very little data was found in current literature about the effectiveness of flipping the classroom, especially at the high school level, these findings were reinforced by two studies. O'Bannon, Lubke, Beard, and Britt (2011) found in a study of achievement in a college technology class using podcast instruction versus lecture instruction that there was no statistically significant difference in achievement between the two groups. In addition, Deal (2007) reported that Appalachian State University (ASU) conducted a study in the spring of 2006 where it compared performance in a traditional lecture course to a podcast lecture course. ASU reported that there was no significant increase in exam performance between the two course types.

When broken down into subgroups, there was no significant difference in achievement between different genders and different lunch statuses. However, statistical analysis revealed that in one case there was a statistically significant difference in achievement based on race/ethnicity, with Caucasians outperforming the other groups (Asian, African American, and Hispanic).

Clark and Mayer (2011) attributed the success of learning to how well-designed and well-implemented the learning activities were. They also said that when the method of instruction stays the same, with only technology introduced into the picture, learning will not change. I believe that, although there was no significant difference in achievement between the two groups, there still were gains in both groups, which indicates that flipping the classroom is a viable option as a teaching strategy based on the data collected. I think the combination of the 4MAT learning cycle and the flipping of the lectures together were mostly effective in producing the desired student learning outcomes as is evidenced by the fact that students not only increased their scores from pre to posttest, but students and parents both agreed that the in-class hands-on inquiry activities were beneficial. The majority of students also reported that their level of understanding of the subject material increased as a result of viewing the different types of videos, and they prefer the flipped class format.

Accountability. Data collected through a student survey and focus group revealed that the majority of students reported accountability issues. Only 10% of the students said they watched the videos 100% of the time. Forty-five percent of the students said they watched the videos more than once on average. In the student focus group, students reiterated that the best advice they would have for other students is to watch the videos. Students reported that the reasons they did not watch the videos were that other afterschool activities got in the way, there was not enough self-discipline, and/or they forgot to watch. Forty-three percent of parents would give the same advice as their child did to others–to watch the videos when assigned and to ask questions as needed.

From my reflections, accountability was one area in which I felt I needed to improve. Merely giving a 1-minute response quiz at the beginning of the next class period is not enough to ensure that all students watch the video. I felt like there needed to be a way to track usage by each student. One way of monitoring student usage might be to embed a quiz into the videos so that each student must take the quiz as they watch.

Although no data were found in the literature that addressed the issue of accountability, Bergmann and Sams (2012, p. 98) acknowledged that this is a question frequently asked of them by other teachers, indicating that it is a concern. Their solution is to have the students take notes as they watch the videos, and notes are checked at the beginning of the next class period. Bergmann and Sams also stated that Ramsey Musallam, a teacher in San Francisco who flips his AP Chemistry classroom, embeds his videos and a Google form on a webpage, so that students respond while or after viewing the videos. Further, for those students who did not watch the videos assigned, Bergmann and Sams (2012) said, “It is as if they had skipped the class in a traditional classroom,” so their alternate solution is to have those students watch the videos at the beginning of the next class, in class (p. 99). This forces these students to sit out of the activities in which the rest of the class is participating, and, instead of completing their homework in class, they must complete it at home.

After teaching ninth graders for 12 years, I consistently observe that since they are coming to me directly from middle school, they have never mastered how to be responsible for their own learning. My observation is that students who did not do well on the 1-minute responses, leading me to believe they did not actually watch the videos, were the same students who only sporadically turned homework in.

I also believe, after flipping the classroom for most of a semester, that the flipped method actually encourages students to become more responsible for their learning as is evidenced by the comments students made in their surveys and focus group session and in my reflective journal. Saltman (2012) stated that research findings, curriculum standards, and common core state standards all agree that the role of learning must be shifted from teachers to students, and that research suggests that "when students manage their own learning, they become more invested in their own academic success" (p. 5). In addition, Saltman said that teachers who choose self-directed learning as a goal for their students must put forth a good amount of effort to help students develop these thinking and self-reliance skills.

Table 22 shows major findings for the theme of accountability and recommendations based on findings.

Table 22

Accountability Major Findings and Recommendations

Theme	Major Findings	Recommendations Based on Findings
Accountability	• Only 10% of students watched videos 100% of the time; the rest less. • 55% of students watched videos more than one time; the rest watched more. • Both parents and students would advise other students to watch the videos as assigned. • Must be a way to track which students watch videos and their level of understanding.	• Embed video quizzes directly into videos; track by student

Accessibility. One of the major themes to emerge was that of accessibility to the videos and the technology needed to view them. The majority of students indicated that they used the computer to access the videos via the Internet the evening that they were assigned. Most students agreed that it was beneficial to be able to view the videos as many times as needed to ensure understanding. Another accessibility issue mentioned by students is that they could not watch the videos at school because of blocked websites. Concerns of parents regarding accessibility were that sometimes the Internet was down or very slow, and some were not able to afford computers or cell phones. Existing literature backs up this claim. O'Bannon et al. (2011) reported that in their study, 33% of participants reported having trouble accessing the podcasts, especially at home via computer. My reflections revealed that I, too, felt accessibility was a big issue. I felt strongly that the only way to ensure equity for all students is for the school to provide all students the same piece of technology to use for the duration of the course.

These findings are consistent with current literature. In Project Tomorrow's Speak Up 2011 Report, students were asked to name the top five obstacles they faced in using technology in the school. Fifty-nine percent of students responded that needed websites are blocked, and 55% stated that they cannot use their technology in the schools (*Learning*, 2011).

In addition, in its 2007 National Summit Conference, the International Society for Technology in Education (ISTE) addressed the issue of students having access to computers. The ISTE asked participants what their top concerns were, and one was that many students still did not have access to computers or Internet outside of the school setting (Davis, Fuller, Jackman, Pittman, & Sweet, 2007).

Schwartzbeck and Wolf (2012), however, said that "Technology and digital learning provide the critical educational support that U.S. students need in order to respond to the increased pressure for greater academic performance and global competitiveness." However, Valadez and Duran (2007) said that providing in-school computers is one thing, but it is essential for students to have access to computers and Internet at home, and that could become a reality through grants, social policies, and district programs.

Since 2008 to the present, the state of South Carolina cut spending per student by 18% (Oliff, Mai, & Leachman, 2012). However, Schwartzbeck and Wolf (2012) suggested that funding related to teacher time could be reallocated:

> Digital learning can positively affect school budgets and teaching practices by shifting the makeup of classes and the approach to learning. As many are finding, a "flipped" classroom model in which students watch or listen to the lecture on video or podcast at home provides teachers with the ability to take on a different role in the classroom with students. Since students can be working on problems or projects or engaging in discussions in the classroom, the teacher becomes more of a facilitator of learning who can guide individuals. This, as well as the opportunity for students to engage in other digital learning opportunities in the classroom in a blended environment, may provide an opportunity to rethink the use of teachers and their time. Rather than taking the place of the teacher, these digital learning models take much greater advantage of the abilities of teachers as professionals. (p. 16)

This suggests that perhaps teachers could become less like instructors and more like guides for students in the classroom, which is exactly what the flipped classroom model looks like. For this reason, I plan to work with the District Office to write grants that will hopefully provide each student in next year's classes a 4G netbook or iPad to use throughout the year so that all have equal access.

Table 23 depicts the findings for the theme of accessibility, along with recommendations for the future.

Table 23

Accessibility Major Findings and Recommendations

Theme	Major Findings	Recommendations Based on Findings
Accessibility	• The preferred method of viewing the videos was via Internet on computer. • 87% of students watch the videos on the evening assigned • Parents and students both said reliability of the Internet is a concern for the flipped class format • Students and instructor recommend school issue computers with Internet access to each student for equal access	• Write grants for 4G netbooks so that each student can be issued a computer to use for the year. • Add closed-captioning to meet ADA requirements

Technical. The majority of students responded positively to technical aspects of the videos. One-hundred percent of the students reported at least a medium level of comfort or above with technology. Sixty-eight percent of the students liked the length of the videos, and reported that the videos created less homework for them overall. This finding is consistent with the existing literature. Bergmann and Sams (2012, p. 99) reported that they found the ideal length for videos is under 15 minutes, preferably under 10 minutes; 100% of students rated the quality of the videos at a medium quality level or above.

Fulton (2012) asserted in her research that students like having a personal relationship with the person narrating the videos. In fact, one student said I could improve my videos by including my picture in a bubble showing me talking. I considered this when I began creating my instructional videos, but decided against it because I did not see that it would add anything beneficial to the video. Pinder-Grover, Green, and Mullunchick (2011) asserted that students reported a preference for having the speaker's picture in the screencast, but that the absence of the picture did not affect how the students retained the material. The majority of students agreed that the pictures and animations assisted them in understanding the concept. This finding is consistent with current research, which says that students report it is helpful for them to see an animation instead of just a static picture (Goldenberg, 2011).

The videos themselves were designed with Mayer's multimedia principles in mind; that is, people are more likely to understand material when they engage in active learning, and multimedia presentations encourage active learning by presenting material in word and picture form (Clark & Mayer, 2011). This is important so the information makes it through the working memory into the long-term memory.

Bergmann and Sams (2012, p. 36) contended that the most daunting task teachers face in the flipped classroom is that of making the videos. However, I did not find this to be a problem. I spent on average two evenings a week creating the videos from existing PowerPoint presentations, and it took less than 30 minutes to create each one. However, I am comfortable with technology and the technical aspects of creating videos.

Table 24 shows major findings for the technical theme, along with recommendations for the future.

Table 24

Technical Major Findings and Recommendations

Theme	Major Findings	Recommendations Based on Findings
Technical	• 100% of students are somewhat to very comfortable with technology • 68% of students say 5-10 minute length of videos is just right • 100% of students say quality of videos was average or better • Majority of students believe that animations/pictures in the video aided them in learning material	• Will work on the technicalities of embedding quizzes in the videos.

Comprehension. Students indicated that comprehension and understanding of videos was a bit of a problem. To begin with, only 19% of students said they felt completely prepared for the next class after watching a video, with 13% not feeling prepared at all. In a related question, when asked to rate the difficulty of performing class activities after watching the videos, only 29% of respondents said it would be somewhat or very difficult, and only 13% said it would be not difficult. Based on the fact that students said they needed more discussion time after the videos, and the fact that I have a couple of students who are struggling with the flipped concept due to access issues, I have decided to do the lectures in class for the remainder of this school year, but to also create videos to put online as supplementary resources. In the future, however, I will return to the complete flipped concept but will utilize the Atkin and Karplus's (1962) 3-phase learning cycle because it is essentially the same as the 4MAT but without Quadrant 4. I plan to embed a video quiz that each student must take during and after watching the video so that they can not only be held accountable for watching the videos, but I can also monitor their comprehension of the material before class.

The majority of students indicated that the small group work was the most effective type of classwork for the learning of material. Llewellyn (2005) agreed, and said that

> The collaborative nature of science and technological work should be strongly reinforced by frequent group activity in the classroom. Scientists and engineers work mostly in groups and less often as isolated investigators. Similarly, students should gain experience sharing responsibility for learning with each other. (p. 58-59)

In addition, Llewellyn stated that group work not only allows students to learn from one another but also to build self-confidence as they work toward a common goal.

Table 25 shows major findings for the theme of comprehension, along with recommendations for the future.

Table 25

Comprehension Major Findings and Recommendations

Theme	Major Findings	Recommendations Based on Findings
Comprehension	• 53% of student admitted they did other activities while they watched the video • Majority of students said their level of understanding of the material overall was better after viewing all types of videos (new material, pre-lab, extra help, classwork review) • The majority of students believe that the flipped class is equal in difficulty to the traditional class • 65% of students said understanding the material during the video was difficult • 90% of students said the discovery activity before the video aided them in understanding the video • 87% of students report that the video prepared them for the next day's class • 42% of students said the video aided them in doing the next day's activities, while 29% said it did not help • 50% of students felt flipped class was more difficult than a traditional class • 52% of students report that small group activities in class most aided them in learning material	• Provide guided note taking worksheet for students to fill out as they watch the videos. • Embed quiz in videos • Spend more time discussing the videos before moving on to class activities.

Pedagogy. Students were asked about their preferences for different types of videos. The main reason students chose to watch the videos was to review for the test. When asked about where they would prefer to have each different form of instruction, the majority of students said they would rather have at-home videos for pre-lab instruction only, with new material lecture, homework review, and extra help instruction occurring in the classroom. Interestingly enough, however, the same students said they preferred the flipped class format. I believe this is due to the fact that they enjoy the in-class small group inquiry activities but recognize that they need a little more help than they are getting currently in digesting the video material, as is evidenced in comments made by students in the survey and focus group.

Another interesting finding was that even though the flipped classroom format was supposed to increase interaction time between students and me, 13% of students felt that they had less time with me; but when I probed deeper in the focus group session, students explained that it was because they were relying more on themselves and their group members than on me.

Parents reported their children seemed to enjoy the flipped class better because of the group work and hands-on activities. This belief is reinforced by current research, which says,

> The flipped classroom pulls together a number of instructional techniques supported by research on learning theory. Limits on video upload capacity means content is chunked into manageable, understandable units. As they determine how often they need to review a video lesson, students must constantly assess their understanding of the material, building thinking skills. With students using classroom time to complete problems demonstrating their understanding, they get immediate feedback on their work, as well as just-in-time support from teachers and peers. They often view the videos together, work in teams in class, and learn through teaching one another via peer tutoring–approaches validated by social learning theory. (Fulton, 2012, p. 23).

When reflecting on my pedagogy, I found that the main problem I encountered in the classroom was that of how the time was spent. Although overall I thought the 4MAT learning cycle method of teaching was extremely effective, I questioned whether or not my students' time could have been better spent in Quadrant 4–where they reflected on, synthesized, and presented what they had learned. I felt that an excess of time (2-4 days usually) was spent reflecting on, creating, and presenting their synthesized information, while the time could have been better spent practicing math problems and reviewing more difficult material.

I do, however, believe that the reflection was a positive experience for the students. I overheard many times one student correcting misconceptions of another as they reflected in small groups. I also believe that introduction of more inquiry into the lessons had a positive effect on the students, especially the discovery activity in Quadrant 1. Students were encouraged to complete the activity and journal their findings, and many students told me that this was helpful to them before they watched the video that night, which reinforces Mayer's (1998) pretraining principle. It was also helpful to me because I could gauge what level of prior knowledge of the subject students had, and could address misconceptions in the videos or during discussion.

At the end of the learning unit, students revisited their initial journal entries, and were encouraged to correct any mistakes or add to what they had written. Research supports the importance of prior knowledge, saying, "By knowing what students already know at the outset of a course, faculty can design more effective learning experiences that facilitate the growth of that knowledge over time" (Boettcher, 2007, p. 4).

Over the course of the semester, I watched as the students went from requiring constant scaffolding during inquiry, to requiring intermittent scaffolding. I attribute this to the fact that they became more comfortable with the inquiry process as the semester progressed, and they also became more confident in their scientific abilities, both in the control and the experimental classes. I tried to create an atmosphere where mistakes were acceptable, as long as the students learned from them, and indeed this seemed to work in the long run. Llewellyn (2005, p. 39) stated that reflection and collaboration are two key components of metacognition, and that metacognition is achieved through the inquiry process via cooperative learning groups and journaling.

Although the flipped classroom model has been criticized for being simply a high-tech version of the traditional classroom lecture (Ash, 2012), I disagree with this perception. Offsetting the lecture to outside of the classroom allows more time in class for inquiry activities, which is an essential part of the 21st Century high school science curriculum (Brown, 2003).

Table 26 shows major findings for the theme of pedagogy, and recommendations for the future.

Table 26

Pedagogy Major Findings and Recommendations

Theme	Major Findings	Recommendations Based on Findings
Pedagogy	• The majority of students use videos to learn new material, clarify material, and to review for a test. • The majority of students prefer in-class lecture for new material lecture, classwork review, and for extra help. However, the majority of students prefer at-home instruction for pre-lab instructions. • 42% of students report interacting with the teacher less in the flipped class format than the traditional format because they are getting help from group members. • The majority of students say that small group inquiry activities in class help them learn material the best. • Only 3% of students said Quadrant 4 synthesis activity benefitted them the most; instructor concurred.	• Use Atkin and Karplus's (1962) 3-step learning cycle model to eliminate Quadrant 4 • Embed reflective activities throughout the learning cycle

Preference. In the end, 58% of the students and 54% of the parents said they would prefer that they/their child be in a flipped class format. Fulton (2012) agreed and said that in one recent study, 84% of parents preferred the flipped classroom format and also stated, "students seem to prefer the flipped classrooms" (p. 24). This same finding was reiterated by Lage et al. (2000) when they said, "The majority of students were favorably impressed by the course" (p. 35).

My reflections lead me to prefer a flipped classroom model, were the students to all have equal access to technology, and this will be the format I pursue for the next school year. However, for the remainder of this semester, I will revert to lecturing in class with the videos as an added resource due to less than 100% accessibility of students to the Internet and to budget constraints within my district.

Table 27 shows major findings for the theme of preference and recommendations based on findings.

Table 27

Preference Major Findings and Recommendations

Theme	Major Findings	Recommendations Based on Findings
Preference	• 58% of students would recommend the flipped class format versus traditional class format to their friends. • 54% of parent would recommend the flipped class format to their child	• For next school year, continue using flipped class format but with netbooks or iPads issued to all students.

Summary

Table 28 shows the complete summary of major findings and recommendations based on the findings.

Table 28

Themes, Major Findings, and Recommendations Based on Findings

Theme	Major Findings	Recommendations Based on Findings
Accountability	• Only 10% of students watched videos 100% of the time; the rest less. • 55% of students watched videos more than one time; the rest watched more. • Both parents and students would advise other students to watch the videos as assigned. • Must be a way to track which students watch videos and their level of understanding.	• Embed video quizzes directly into videos; track by student
Accessibility	• The preferred method of viewing the videos was via Internet on computer. • 87% of students watch the videos on the evening assigned • Parents and students both said reliability of the Internet is a concern for the flipped class format • Students and instructor recommend school issue computers with Internet access to each student for equal access	• Write grants for 4G netbooks so that each student can be issued a computer to use for the year. • Add closed captioning for ADA
Technical	• 100% of students are somewhat to very comfortable with technology • 68% of students say 5-10 minute length of videos is just right • 100% of students say quality of videos was average or better • Majority of students believe that animations/pictures in the video aided them in learning material	• Will work on the technicalities of embedding quizzes in the videos.
Comprehension	• 53% of student admitted they did other activities while they watched the video • Majority of students said their level of understanding of the material overall was better after viewing all types of videos (new material, pre-lab, extra help, classwork review) • The majority of students believe that the flipped class is equal in difficulty to the traditional class • 65% of students said understanding the material during the video was difficult • 90% of students said the discovery activity before the video aided them in understanding the video • 87% of students report that the video prepared them for the next day's class • 42% of students said the video aided them in doing the next day's activities, while 29% said it did not help	• Provide guided note taking worksheet for students to fill out as they watch the videos. • Embed quiz in videos. • Spend more time discussing the videos before moving on to class activities.

(continued)

Theme	Major Findings	Recommendations Based on Findings
	• 50% of students felt flipped class was more difficult than a traditional class • 52% of students report that small group activities in class most aided them in learning material	
Pedagogy	• The majority of students use videos to learn new material, clarify material, and to review for a test. • The majority of students prefer in-class lecture for new material lecture, classwork review, and for extra help. However, the majority of students prefer at-home instruction for pre-lab instructions. • 42% of students report interacting with the teacher less in the flipped class format than the traditional format because they are getting help from group members. • The majority of students say that small group inquiry activities in class help them learn material the best. • Only 3% of students said Quadrant 4 synthesis activity benefitted them the most; instructor concurred.	• Use Atkin and Karplus's (1962) 3-step learning cycle model to eliminate Quadrant 4 • Embed reflective activities throughout the learning cycle
Preference	• 58% of students would recommend the flipped class format versus traditional class format to their friends. • 54% of parent would recommend the flipped class format to their child	• For next school year, continue using flipped class format but with netbooks or iPads issued to all students.

Implications for Policy and Practice

This research provides data about perceptions and achievement of the flipped classroom model. The findings, while not generalizable to all situations, do provide high school science teachers and other subject teachers a window into what needs to be considered when deciding whether or not to flip their classrooms. Some issues that will arise and things that need to be considered are accessibility to needed technology, how to hold students accountable for the flipped portion of the class, the technical issues that must be considered when creating instructional videos, what methods work best in aiding student comprehension of a particular subject, and overall pedagogy of the model. In addition, student attitudes and responses to surveys and focus groups will give an instructor insight into what beliefs and thoughts students hold with regard to the flipped model.

As a result of my findings, and the fact that a couple of students and parents are opposed to the flipped format due to access issues, I will do a few things differently for the remainder of this school year. First, I plan to continue using the 4MAT learning cycle model for instruction. I will shorten the Quadrant 4 reflective activities to 1-day activities but embed more reflective activities throughout the learning cycle. Second, I plan to follow the students' advice and change instructional delivery of new material, homework review, and extra help back to the classroom setting, while continuing to do pre-lab instruction at home via video. However, I plan to continue creating the videos and placing them online for students to use as a supplement to my instruction or to use for when they are absent. Pinder-Grover et al. (2011) said that their research indicates a positive impact of using screencasts as supplementary material to enhance student learning, especially for struggling students. Pinder-Grover et al. also stated that by creating and publishing screencasts for students the playing field is leveled for all students, and I concur. However, they also cautioned that the success of the technology resource is dependent on aligning it with the learning goals for the students.

Next year, however, I will change the learning cycle model I use to Atkin and Karplus's (1962) 3-phase cycle that was discussed in the literature review, which is essentially the same as the 4MAT, but without Quadrant 4. I feel that the reflective portion of the class could be accomplished in other ways, perhaps on a daily basis. I will continue to utilize the flipped class format, but will ask our administration to separate the flipped class out in the registration guide so that only students who want to be in the class will be placed in the class. If I am unsuccessful in getting netbooks or iPads for next year, then I will recommend that the school list the flipped class separately in the registration guide, and stipulate that students must have reliable access to their own technology in order to participate in the flipped class. I can thus ensure that students and parents are onboard from day one and can also ensure that students have the needed technology to excel in this type of classroom setting.

Also, now that I know that the videos are great supplementary resources, I plan to make them available to all levels of Physical Science classes next year so all students can benefit from them.

In order to ensure continuous improvement of the process of flipping the classroom, the same rigorous research process will be completed next year on the flipped classroom, with current recommendations incorporated, so that the flipping process can be refined as needed to best meet the needs of my students.

Future Research

Based on the findings of this study, I would recommend that future research extend the findings of this study. The suggestions for future research are outlined in Table 29.

Table 29

Recommendations for Future Research

Subject	Recommendation(s)
Demographic Data	• Expand the study of effects of flipped treatment by gender on achievement • Expand the study of effects of flipped treatment by race/ethnicity on achievement • Expand the study of effects of flipped treatment by lunch status on achievement • Compare the effects of grade in school on achievement in flipped classroom
Accountability	• Test the effects of adding embedded quizzes to videos and/or guided note-taking during videos on achievement in flipped classroom
Comprehension	• Test the effects of embedded quizzes in videos on achievement in flipped classroom • Test the effects of adding closed captioning to the videos on achievement in flipped classroom
Accessibility	• Repeat this study, testing the effects of issuing computers/iPads to students on achievement in flipped classroom
Technical	• Repeat this study, but add closed captioning to videos to test effects on achievement in flipped classroom • Repeat this study, but change the format of videos to test effects on achievement in flipped classroom
Pedagogy	• Repeat this study, but change the in-class method of teaching, within the flipped class format, to test effects on achievement in flipped classroom
Other	• Repeat this study, but expand sample size and/or increase the length of the study

Conclusion

Elmore (2009) said that there are three ways to improve student learning: “raise the level of the content that students are taught, increase the skills and knowledge of the instructors, or increase the level of active learning in the classroom" (p. 249). The flipped classroom is a model that is designed to offset passive lecture-type activities into the home, and to create more time for in-class active learning activities.

This format not only appeals to the Generation Z students' particular learning styles, but also is consistent with 21st Century science pedagogy which says that instruction should be student-centered, the teacher should be a facilitator of the learning process, students should take control of their own learning through acquisition of metacognitive skills, and learning should occur through inquiry activities. The flipped class meets all of the qualities of a 21st century science pedagogy: It is student-centered with the teacher as the guide on the side, students are taught to take control of their own learning through watching videos on class material outside of the classroom, and most in-class activities are active learning inquiry activities.

In reviewing the findings of this research study, it is clear that the flipped classroom format can be successful if a variety of factors are taken into consideration– accessibility, accountability, technology, comprehension, pedagogy, and preference. Students must have access to the needed technology, must be held accountable for watching the videos as assigned, the videos must be produced in way that optimizes student learning (Mayer's multimedia learning principles), discussion must take place after students watch the videos to ensure comprehension, and an active learning pedagogy must be employed in the classroom.

In conclusion, we cannot expect better results in the classroom by merely using a new piece of technology or a new type of pedagogy; rather, it is the synergy between the technology, the pedagogy, and the theories of learning that ultimately make the difference in the classroom.

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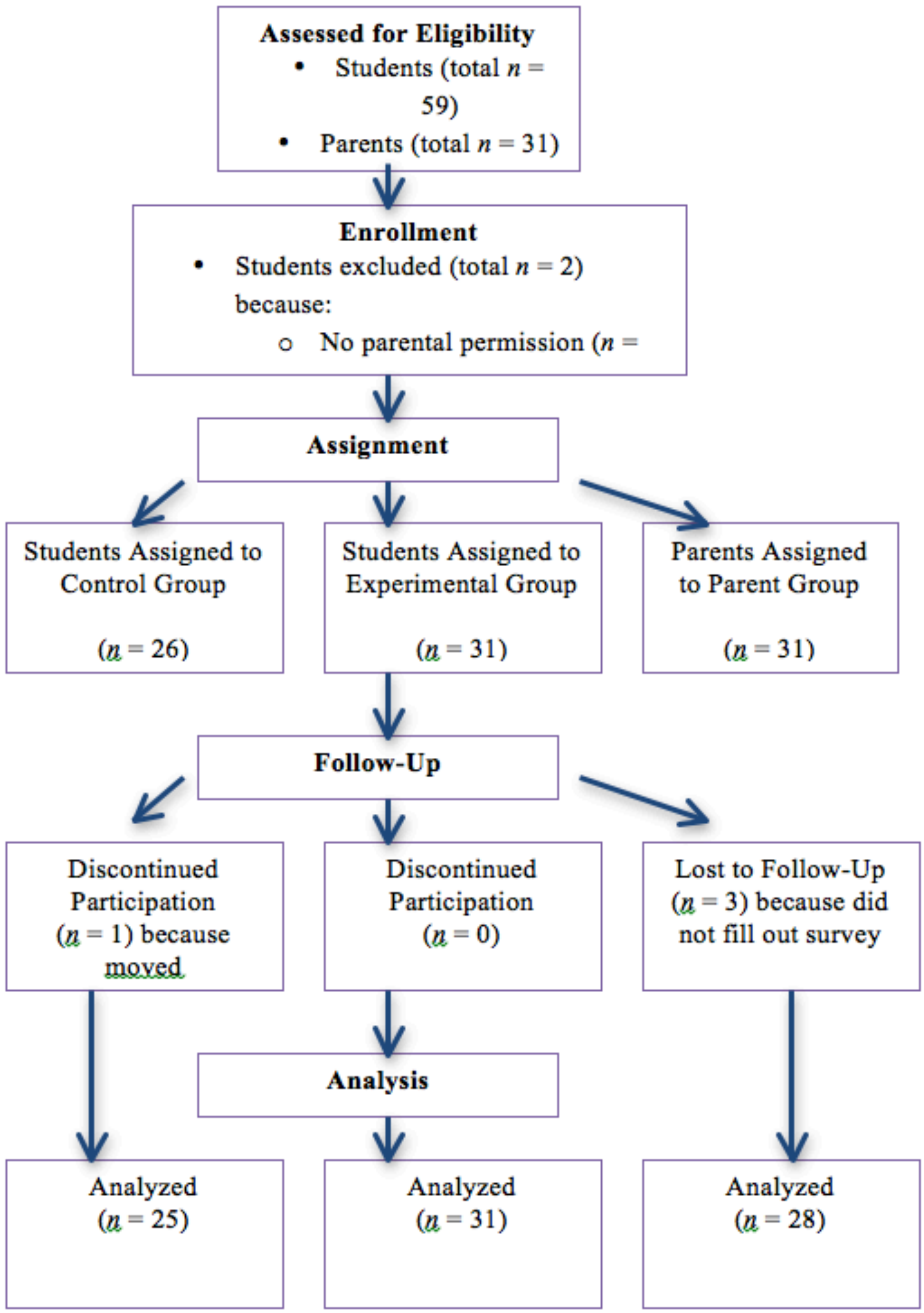
Appendix A

Flow of Participants

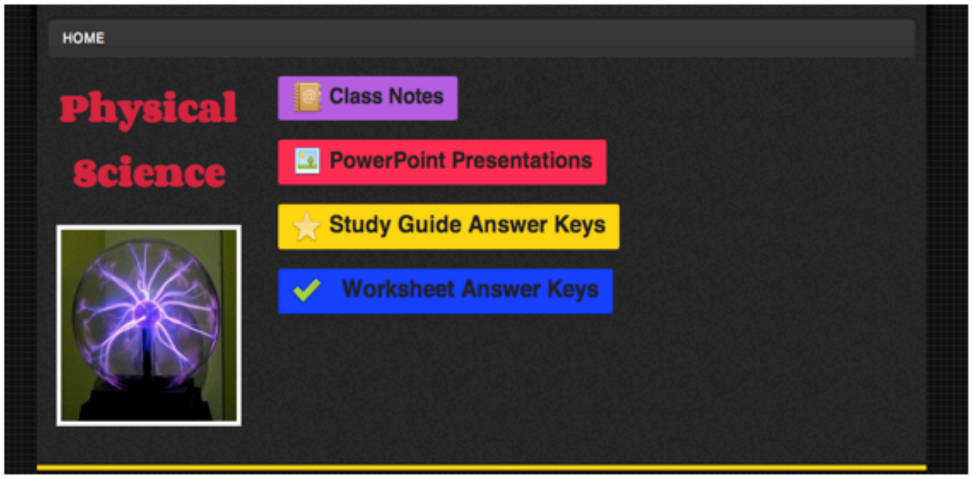
Flow of Participants



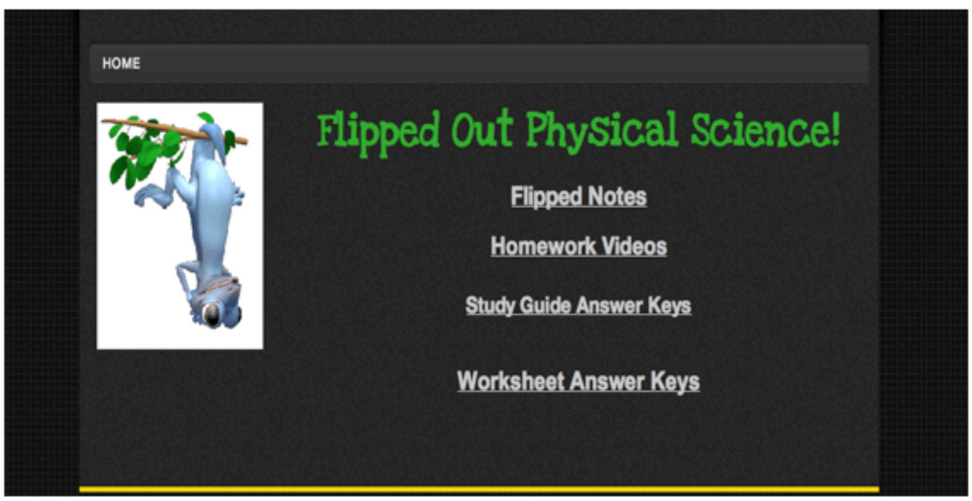
Appendix B

Teacher Website

Regular Physical Science Class Website
www.scienceiskool.com



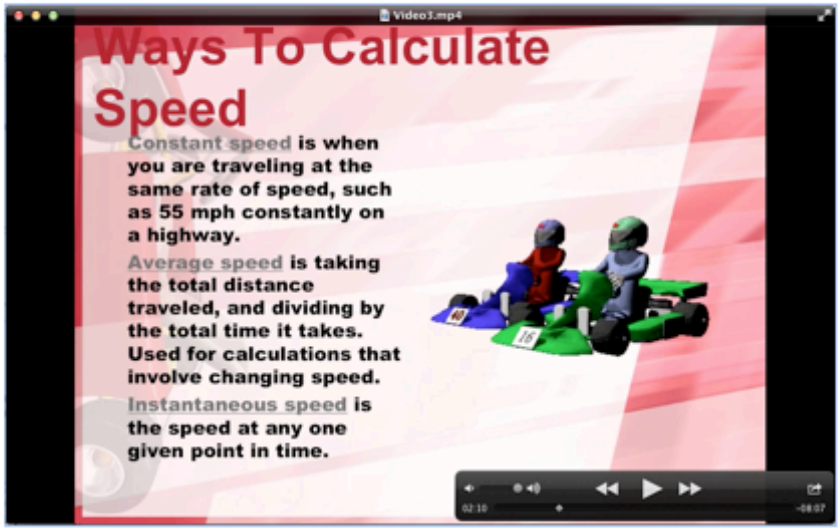
Flipped Physical Science Class Website
www.scienceiskool.com



Appendix C

New Material Lecture Video Screencasts

New Material Lecture Video Screencasts



Appendix D

Student Online Survey

Flipped Class Student Survey

Please answer each question as you reflect on your flipped class experience.

DEMOGRAPHICS

1. What is your gender?

- Female
- Male

2. Please specify your race/ethnic group.

- African American
- Asian
- Caucasian
- Hispanic
- Other:

3. What is your lunch status for this school year?

- Free lunch
- Reduced-price lunch
- Full-price lunch

AT-HOME PART OF FLIPPED CLASS

4. Please rate your comfort level when using technology, such as computers, smartphones, iPads, etc.

	1	2	3	4	5	
Not comfortable	●	●	●	●	●	Very comfortable

5. When viewing the assigned homework videos, what form(s) of technology did you use? Check all that apply.

- Computer
- Smartphone
- iPad
- iPod
- Other:

6. As you watched the videos, what else did you do? Check all that apply.

- Took notes
- Watched television
- Listened to music
- Surfed the web
- Participated in a social network (Twitter, Facebook, etc)
- Only watched video; did nothing else
- Didn't watch videos; used another resource to learn the material
- Other:

7. When a video was assigned for homework, approximately what percent of the time did you actually view the video?

- 0% of the time
- 1-25% of the time
- 26-50% of the time
- 51-75% of the time
- 76-99% of the time
- 100% of the time

8. On average, how many times did you watch each assigned video?

- 0 times
- 1 time
- 2 times
- 3 times
- 4 times
- 5 or more times

9. When did you actually watch the assigned videos? Check all that apply.

- During the school day on the day they were assigned
- The evening they were assigned
- The next day before the class in which it was due
- Later - after the due date
- I never watched the videos

10. For what purpose(s) did you watch the videos? Check all that apply.

- To learn new material
- To review material for a test
- To clarify material you didn't understand

11. Overall, how would you rate the length of the videos?

- Too long
- Too short
- Just about right

12. Overall, how would you rate the quality of the videos? (audio and video)

	1	2	3	4	5	
Poor quality	○	○	○	○	○	Excellent quality

For each of the following, check the circle that BEST describes your level of understanding, on average, of the information contained in the videos after viewing:

	1 - Didn't understand	2	3	4	5 - Completely understood
13. Textbook chapter lecture	○	○	○	○	○
14. Pre-lab instruction	○	○	○	○	○
15. Review of work done in class	○	○	○	○	○
16. Extra help for a topic	○	○	○	○	○

For each of the following types of instruction, choose the circle that BEST describes whether you prefer in-class instruction or at-home video instruction.

	In-class instruction	At-home video instruction
17. Textbook chapter lecture	○	○
18. Pre-lab instruction	○	○
19. Review of work done in class	○	○
20. Extra help for a topic.	○	○

21. Which method of viewing the videos at home is your preferred medium for viewing?

- Internet
- CD
- DVD
- Flash drive
- Other:

22. Compared to traditional homework assignments, how would you describe the flipped class video homework?

- I spend more time doing traditional homework assignments
- I spend more time watching video homework assignments
- I would spend about the same amount of time on each

IN-CLASS PART OF FLIPPED CLASS

23. How would you rate the level of rigor (difficulty) of the flipped science class compared to a traditional science class?

	1	2	3	4	5	
Not as difficult	○	○	○	○	○	Much more difficult

24. Which type of classwork did you find to be the MOST effective in helping you learn the material in the flipped science class? Check only one.

- Whole-class discussions
- Small-group work
- Laboratories
- Journaling
- One-minute quizzes at beginning of class
- Student presentations
- Individual projects
- Other:

25. Compared to a traditional science class, how would you rate the amount of time spent individually interacting with the teacher?

- More time
- Same amount of time
- Less time

26. As you watched the videos on the new material being presented, how difficult was it to understand the new material? Choose the circle that BEST applies.

	1	2	3	4	5	
Not difficult	●	●	●	●	●	Very difficult

27. How much did the discovery activity done before viewing the video assist you in your understanding of the video?

- It made understanding the video much easier
- It didn't help me understand the video at all
- It somewhat helped me understand the video

28. How well did the assigned videos you watched at home prepare you for the next day's class?

- I felt completely prepared
- I did not feel prepared
- I felt somewhat prepared
- I didn't watch the videos

29. After you watched the videos that presented new material, how difficult was it to understand and perform the next day's activities? Choose the circle that BEST applies.

	1	2	3	4	5	
Not difficult	●	●	●	●	●	Very difficult

OVERALL FLIPPED CLASSROOM EXPERIENCE

30. Overall, how useful did you find the material you learned in the flipped science class?

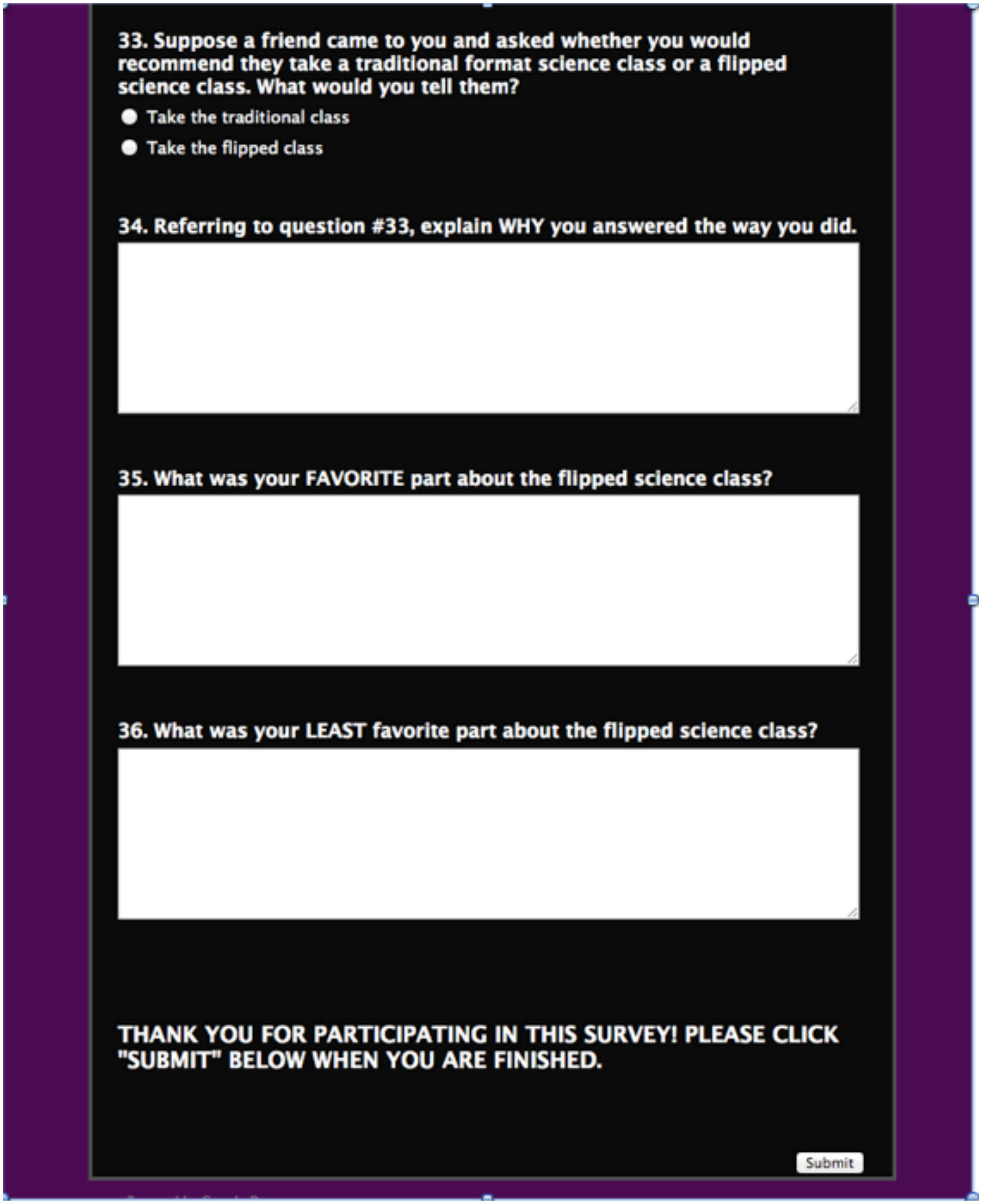
	1	2	3	4	5	
Not useful	●	●	●	●	●	Extremely useful

31. Overall, did you find that the material you learned in the flipped science class could be related to real life? Choose the circle that BEST applies.

	1	2	3	4	5	
Not at all related to real life	●	●	●	●	●	Extremely related to real life

32. Overall, how interesting did you find the material you learned in the flipped science class? Choose the circle that BEST applies.

	1	2	3	4	5	
Not at all interesting	●	●	●	●	●	Extremely interesting



33. Suppose a friend came to you and asked whether you would recommend they take a traditional format science class or a flipped science class. What would you tell them?

- Take the traditional class
- Take the flipped class

34. Referring to question #33, explain WHY you answered the way you did.

35. What was your FAVORITE part about the flipped science class?

36. What was your LEAST favorite part about the flipped science class?

THANK YOU FOR PARTICIPATING IN THIS SURVEY! PLEASE CLICK "SUBMIT" BELOW WHEN YOU ARE FINISHED.

Submit

Appendix E

Parent Online Survey

Parent Flipped Class Survey - Mrs. Howell's Science Class

First, read the definitions below. Then, carefully read each question, and answer as honestly as you can.

Definitions

Flipped Classroom - one in which what traditionally occurs in the school setting, such as lecture-type activities, now occurs at home via video. Conversely, what has traditionally occurred in the home setting, such as homework-type activities, now occurs in class. This is your child's class format.

Traditional Classroom - one in which lecture-type activities occur in the classroom, and homework-type activities occur at home.

1. When you first heard that I would be using the flipped classroom format, what did you think?

2. To your knowledge, did your child watch the videos as assigned?

- Yes
- No
- I have no idea

3. Given a choice, would you rather your child be in a traditional science class, or a flipped science class?

- Traditional
- Flipped
- I see no difference between the two

4. Did your child ever talk about their flipped science class at home? Please explain how (what they said) if your answer is "yes."

5. Since the beginning of 9th grade, have you noticed a change in your child's attitude toward science?

- ○ Yes - a positive change
- ○ Yes - a negative change
- ○ No change

6. Suppose a friend of yours has a child going into 9th grade next year, and will be taking the flipped science class. What advice do you have for them?

7. Was access to technology (computer, smartphone, iPad, etc) a problem for your child when trying to view the science videos? Explain.

8. Do you have any other comments / concerns you would like to share with me about the flipped classroom?

9. Did your child have a hard time accessing the videos from home? If you answer "yes", please explain how and why.

Submit

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Appendix F

Student Focus Group Questions

Student Focus Group Questions

Read: ***A flipped class is defined as one where lecture-type activities take place via video outside of the classroom setting and homework-type activities take place in the classroom. A traditional class is defined as one where lecture-type activities take place in the classroom and homework-type activities take place outside of the classroom.***

1. What did you think when you first heard that I would be teaching this course differently than a normal course?

2. Based on what you have experienced so far in this course, what advice would you give another student who wants to take the flipped course next year?

3. Do you think ninth graders have the self-discipline it takes to do the work at home on their own?

4. How challenging was this class to you? Explain.

5. Do you feel that the flipped class format helps or harms you if you miss a class? Explain.

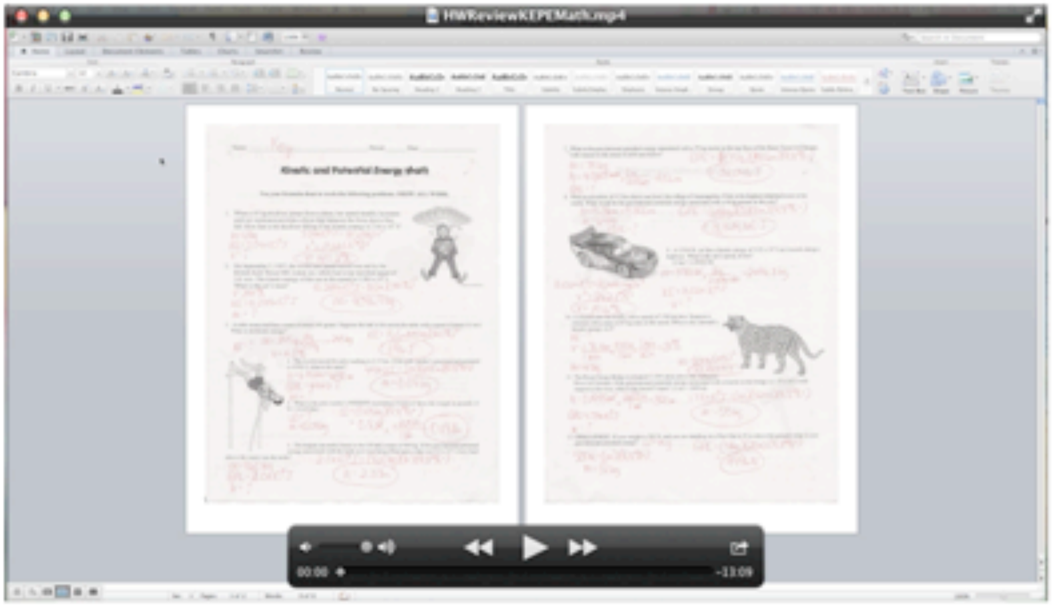
6. Do you feel that doing your homework activities in class as opposed to at home is beneficial to you? Discuss.

7. Is there anything you feel I could have done differently to make this class better?

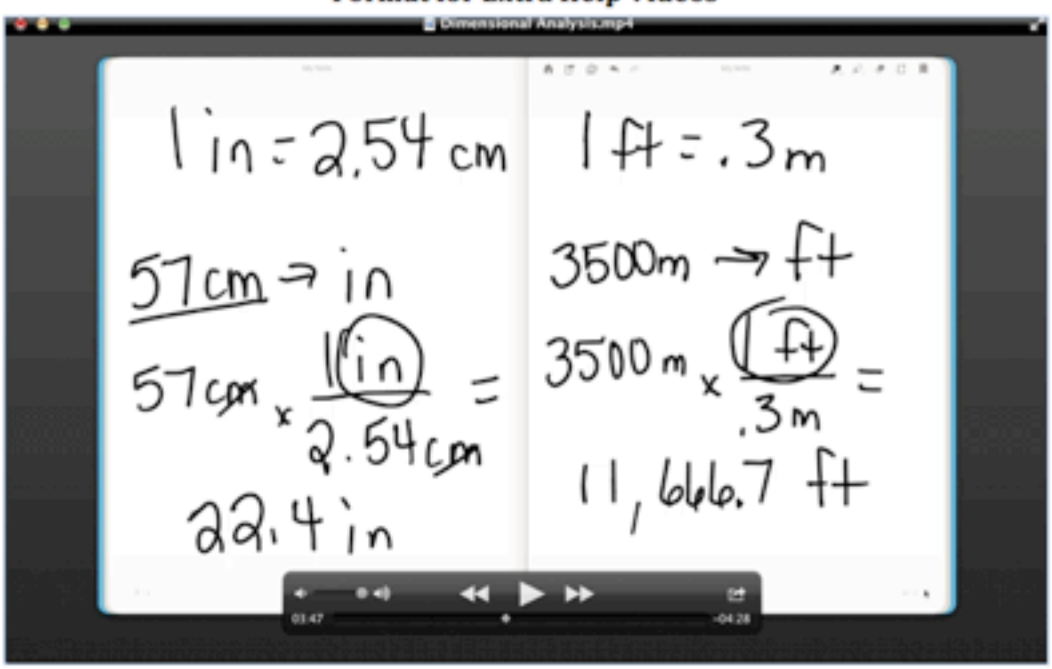
Appendix G

Format for Work Review, Extra Help, and Pre-lab Videos

Format for Homework Videos



Format for Extra Help Videos



Format for Pre-lab Videos