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LEARNING STYLE RELATIONSHIP TO MOTIVATION AND SUCCESS IN THE FLIPPED VS NON-FLIPPED CLASSROOM

by

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LEARNING STYLE RELATIONSHIP TO MOTIVATION AND SUCCESS IN THE FLIPPED VS NON-FLIPPED CLASSROOM

Shannon Seaver

This research paper will provide a brief overview of what a "flipped classroom" is and the variations of it. It will address whether a flipped classroom is a possible way of addressing students of all learning styles and if all learning styles are motivated in a flipped classroom. The VARK learning style inventory will be given to all students in four College Algebra Prep classes. Two classes will be the flipped "inverted" style of classroom and the other two will be the traditional (control) style of classroom. All students in both formats will also be given a periodic survey to examine motivation levels. Lastly, all summative tests given during this grading period (1st quarter) will be examined to see if learning styles and flipped classrooms can affect the outcome of student grades.

Approved by:

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Chapter 1: Introduction

Flipped classrooms have become popular in education today. In a survey of 2,358 educators conducted by Flipped Learning Network and Sophia in February 2014, it was noted that the percentage of teachers who have flipped a lesson in their classroom has increased from 48% in 2012 to 78% in 2014. Of those teachers, 98% flipped their classroom on their own initiative. Also of note from the survey, 90% of the educators surveyed indicated that they have experienced an increase in engagement and 71% noticed an increase in performance in formative assessments (FLN and Sophia, 2014).

There are many different variations of "flipped" classrooms. Some are just simple reversing of when the lecture is watched and when the independent work is done. While this method gives the student more access to the teacher during independent work time, the method of teaching really hasn't changed.

Many teachers who are flipping their classroom are doing more.

> "What we're seeing is a teacher spending a year or two doing 'Flipped Class 101,'" says Jonathan Bergmann, coauthor of *Flip Your Classroom: Reach every Student in Every class Every Day*. "Then they move into project-based learning, inquiry-based learning. It's causing them to reinvent themselves, to have a completely student-centered, learner-centered classroom, as opposed to what we have in most schools, which is a teacher-based model."(Hennick, 2014)

Some questions arise. Exactly what is a flipped classroom? Does it positively affect all students? This is a common concern for many educators who are considering using the flipped structure. Students with diverse backgrounds and learning styles need to be considered when changing the structure of a classroom.

Statement of the Problem and Research Questions

Many classrooms are using "flipped" structures in which students are watching prerecorded lectures at home and doing labs and assignments in class. Teacher and administrators have often embraced the flipped classroom without quantitative research that shows its effectiveness. With the influence of No Child Left Behind and the need to address the learning styles of all children, a concern should be for students that possibly may not do well in a flipped classroom.

My background in industrial engineering plays a very important role on how I evaluate projects. I want to know if flipping my classroom is truly worth my time and resources before I proceed with flipping my classroom or convince others to do so as well. In the private sector, companies will often not approve a project unless there is a two year payback or less. In education, we conduct a cost-benefit analysis and would measure success on the amount of resources spent (time and cost) vs the academic gains by students.

The purpose of this research is twofold: (1) to investigate whether or not learning styles affect how well students learn in a flipped classroom and (2) to investigate whether students are more motivated to learn in a flipped classroom vs. a traditional classroom. The research questions that will guide this research are:

- What is a flipped classroom? Are there variations in a flipped classroom? Why do teachers adopt one variation over another?
- While flipped classrooms have become a popular method of teaching in math classrooms today, do they work well for all students?
- Is a student with a certain learning style, based on VARK Learning Styles Inventory, more likely to score higher in formative and summative assessments than students in a non-flipped classroom?

- Is a student with a certain learning style, based on VARK Learning Styles Inventory, more likely to be more motivated in a flipped classroom vs motivation of students in a non-flipped classroom?

Significance of the Research Problem

It seems the rationale for switching to a flipped classroom has been mostly influenced by other teachers who claim success, or anecdotal reports. This research is being done with the hope of determining the effectiveness of this instructional change.

We also need to consider if flipped classrooms are valid for all types of learners. My school district is interested to see if there is a way to screen students before they register for a flipped classroom that will indicate whether they can be successful in that setting. The first step of doing this is to explore the types of learning styles of students enrolled in the flipped class and see if it affects their academic outcome. This research is being done with hope of exploring the possibility of developing a screening test for students before they register for a flipped classroom so that counselors can advise accordingly.

Assumptions

- All students enrolled in College Algebra Prep have passed all their algebra and geometry prerequisites to this class
- There will be some variance within the classroom based on individual students and their attitudes, efforts, and abilities.
- Ethical treatment and confidentiality of all the students will be maintained.
- Students are being honest and ethical in their test completion and coursework.

- Students enrolling in College Algebra Prep are being randomly distributed among the 6 sections being offered.

Limitations

- Students will be assigned to the classroom based on scheduling.
- The research will be done at a large urban high school because that is where I work.

Delimitations

The definition of learning styles will be limited to those that are defined in the VARK Learning styles inventory that was freely available for use. This was chosen because the number of participants available at the time of research will only allow an inventory with four results. Many more participants would be needed for statistical purposes if other inventories were chosen.

Chapter 2: Literature Review

Definition of a Flipped Classroom

The "Flipped" classroom has become a hot topic in education literature. As of this writing, there were 285 published resources that could be purchased through Amazon's website. A July 2, 2014 Google search on "flipped classroom" resulted in over 1.6 million results. Along with so many results, there are several interchangeable words used in place of "flipped" such as blended and inverted. There are also a variety of definitions as to what is considered "flipped".

Perhaps the most popular definition is an i*nverted – flipped* or *traditional flipped* design. In this design, lectures are watched at home, most of the time from an online video, and traditional homework is completed in the classroom. (Lage, 2000; Strayer, 2012; Glynn, 2013; Lavelle, 2013; Siegle; 2013; Gardner, 2012; Goodwin, 2013; Fulton, 2012; Edina Public Schools, 2013; Byron High School Math Department, 2014) Students are expected to take notes and learn the introductory material before they come to class. Often this design has some kind of online discussion or notebook checks to hold students accountable for watching the videos.

A variation of inverted classrooms is the *blended* classroom. In a meta-analytic study of blended classrooms, Arbaugh (2014) defines blended as a course that combines online learning with face-to-face instruction, but 20-79% of the instruction takes place online. This type of classroom may use the internet to deliver lectures just as in the inverted classroom, except that it cuts classroom time or face-to-face time down to allow flexibility for students with busy schedules (Dziuban, 2004; Edina Public Schools, 2013). In one study, Dorr (2013), stated her classroom was "flipped" by having all the lectures outside the classroom, while keeping face-to-face time a more student-directed time. Students gave her feedback through the use of "clickers"

to help her determine what topics need the most coverage. One could argue that "inverted" or "flipped" classrooms are really a subset of "blended" classrooms.

Flipped Mastery is a flipped classroom that allows students to work at their own pace within boundaries. Once students have "mastered" predetermined objectives, they are able to continue on to subsequent objectives. In this design, students still watch the video lectures at home but complete all other work in the classroom with the help of their peers or instructors (Bergman, 2012; Davies, 2013; Byron High School Math Department, 2014).

The Byron High School Math Department also defined three other flipped designs (2014). *The Peer Instruction Flipped Classroom* design has students learn the basic material and complete coursework at home while using classroom time to have students convince their peers that they were correct in their answers and methods. In a *Problem Based Learning Flipped Classroom* design students explore an issue and learn through the process. At some point in their problem, students watch a video to give them the instruction that they need to solve the problem. Lastly, an *Inquiry Based Flipped Classroom* design introduces a topic through a video that engages their interest and then class time is used to explore the concept and explain what is going on.

In one study, the classroom was considered "flipped" when assigned tasks were completed before the lecture was given in the course. This would include reading, pre-class review, and corrections of graded assignments (Laman, 2010). There are other variations of the flipped classroom not mentioned in this paper. This leads to the question, why are there so many definitions of flipped classrooms? Which one is best? Arbaugh (2014) states, "This inability to provide guidance to educators and administrators leaves those practitioners in the position of having to make decisions based on factors such as personal preference, institutional convenience,

administrative edict and access, rather than necessarily what is best for the learners." Recently at the Flipped Class Conference in Woodland Park Colorado, teachers gathered to create a clear definition of what flipped really was. Bergmann et al (2013) described the flipped classroom as:

- A means to INCREASE interaction and personalized contact time between students and teachers.
- An environment where students take responsibility for their own learning.
- A classroom where the teacher is not the "sage on the stage", but the "guide on the side".
- A blending of direct instruction with constructivist learning.
- A classroom where students who are absent due to illness or extra-curricular activities such as athletics or field-trips don't get left behind.
- A class where content is permanently archived for review or remediation.
- A class where all students are engaged in their learning.
- A place where all students can get a personalized education.

It is not:

- A synonym for online videos. When most people hear about the flipped class all they think about are the videos. It is the interaction and the meaningful learning activities that occur during the face-to-face time that is most important.
- About replacing teachers with videos
- An online course
- Students working without structure.
- Students spending the entire class staring at a computer screen.
- Students working in isolation.

Flipped Classrooms are Not New

Some literature resources claim that flipped instruction has really been around for decades. Gardner (2012) stated, "It would be inappropriate to view the modern inverted classroom as a pedagogical change; rather it is a technological change arising from the proliferation of high-speed internet access, a decrease in the cost of networked mass storage, and a decrease in the cost of video production." Strayer (2012) stated:

"Perhaps the inverted classroom design has been around for decades as teachers have required students to read course material before coming to class and engage the concepts at a deeper level during class. In addition, some could say that teachers who used educational television or

computer-assisted instruction during the past 40 years of educational technology use were inverting their classrooms. However, what makes the concept of the inverted classroom as presented in this article novel is the regular and systematic use of interactive technologies in the learning process" (p.172)

Why Do Instructors Choose to Flip?

In reviewing the literature, several themes arose from the reasons given to flip. The common themes were to improve academic outcomes, student differentiation, improve instructor-student interaction and classroom management, and lastly, flip the classroom for administrative reasons.

The most common reason for an instructor to flip their classroom was to improve academic achievement (Davis, 2013). Some subcategories of this were to increase their ability to offer a more problem solving and critical thinking activities in the classroom without sacrificing content (Lage, 2000; Gardner, 2012) and higher student-student interaction which improved problem solving skills, team work, creativity and innovation (Bergmann, 2012; Laman, 2010). Another reason was to provide more reading and writing activities to provide a broader world view (Laman, 2010). Absenteeism and lack of homework completion was a concern in other studies (Alvarez, 2011; Forsey, 2013). Ineffectiveness of homework was another reason behind switching to a flipped design to utilize classroom time to do independent work and to improve timely feedback.(Goodwin, 2013) In general, Wilson (2013) stated that the goal was to increase student interest, engagement and retention of information. Arbaugh (p. 5, 2014) stated that "The advantages of blended learning environments may reflect differences in content, pedagogy, or learning time rather than the delivery medium."

Another way to improve academic achievement is to improve student differentiation. Some researchers stated that when flipping their classroom, they wanted to offer different options for learning each topic which would allow for different learning styles (Lage, 2000). It also allowed students the flexibility to learn when they were ready and work ahead if they

wanted (Gardner, 2012, Bergmann, 2012). They could break down direct instruction into more engaging bites of information and students could pause and rewind whenever they needed to, not having to frantically write notes and miss important information (Goodwin, 2013; Bergmann, 2012). Flipping the classroom allowed instructors to work more one-on-one with students who needed extra help and intervention (Bergmann, 2012). For students who experienced higher absenteeism because of sports or other issues, making up coursework would be much easier in the flipped classroom (Lage, 2000; Bergmann, 2012)

Improving teacher-student interaction in the classroom was the third theme to come from the literature (Lage, 2000). Today's students speak the language of technology and flipped classrooms use this language (Bergmann, 2012). In traditional lecture-style classrooms, instructors spend the majority of their time talking "to" students, not talking "with" students. Instructors in the flipped format are better able to respond to student's emotional and learning needs (Goodwin 2013). Because of the improved interaction and one-on-one time, student could experience less frustration which would then in turn improve classroom management (Alvarez, 2011). Some students who experience frustration can act out and/or give up on the work. That leads to higher failure rates; therefore, another reason given was to decrease failure rates (Alvarez). The need for a student to have an "audience" would be eliminated because of the small group and independent work style of the classroom (Bergmann, 2012).

Administratively, instructors can spend less time "prepping" because most of their prep work would have been done before the course began (Lage, 2000) It would be easier to hire, and retain substitute teachers as well as make it easier to continue on with content in the classroom when instructors have to be absent (Alvarez, 2011; Bergmann, 2012). In a post-secondary setting, cost savings were reasons to switch to a flipped classroom. It reduced classroom space and

instructional time (Gardner, 2012). It also can shrink the perceived size of large classrooms in the college setting for students (Laman, 2010). One secondary school stated they flipped their classrooms because of a lack of funding for curriculum (Fulton, 2012). Lastly, flipping made the classroom more transparent to parents, even allowed them to learn the material so that they can help support their children's education (Bergmann, 2012; Alvarez, 2011).

Although there were many reasons and advantages to flipping, an instructor needs to address the following considerations. First, everyone in the classroom will need to have access. If they do not, it has to be provided for them by either loaning them the technology or providing access to the technology before and after school hours. Second, students need to watch the material in order to get the direct instruction. Often this needs to be enforced. Enforcement can come in the form of quizzes, notes or leaning management software that can report whether the video was watched or not. Lastly, while flipping a classroom can reduce preparation time in the long run, it is very labor intensive during the startup phase. The instructor not only has to know how to make the videos and online content but they may have to spend the time editing it as well (Gardner, 2012; Siegle, 2013).

Results of the Studies within the Literature about Flipped Classrooms

The studies written about in the literature reported very few results except from surveys and student perceptions. Arbaugh (2014), who conducted a literature study to find if there were factors that were unique to blended learning that would influence instructional effectiveness, found that "although blended formats tend to be viewed favorably relative to online offerings, researchers tend to present blended designs descriptively rather than as theoretically derived and tested" (Arbaugh, p.6).

In the survey driven study, Forsey (2013) reported that "students appreciated flexibility, richness and productivity" while getting more out of their face-to-face time with their instructor. He also stated that students were "experiencing an increase in the amount of leaning time which they appear to be doing because the material is so clearly laid out for them and structured in ways that allow them to feel a sense of achievement when they have completed the set tasks" (Forsey, 2013, p. 481). Wilson (2013) also indicated that students responded that the activities in their flipped course had a positive effect on their ability to learn.

In Gardner's (2012) study, a post-secondary agricultural economics class had survey results that 78% of the students who took the flipped class agreed or strongly agreed that online videos help them learn course concepts (only 47% of those same students watched most of the videos, however), and 54% of students felt that they learned more. In the same study, 64% of the students felt that the inverted classroom led to higher grades, 72% believed the course should continue to be taught inverted, and 62% believed the professor should invert other courses (Gardner, 2012).

Kim (2014) conducted a comparison analysis of three different blended learning formats in three different subject areas in a post-secondary level school. Kim stated that response from students in the flipped classroom indicated that they perceived the flipped classroom activities as more student-oriented than traditional class activities. Students also felt that the class environments were very open and their contributions were acknowledged by other participants. Students felt that assignments challenged them to construct solutions and "overall the flipped classroom assignments helped students to regulate learning by self or by peers in terms of goal setting, monitoring their progression, and evaluating their own achievements."

In a study of an undergraduate statistics course, Wilson stated that exam scores were on average 6.73 points higher in the flipped classroom than in the traditional classroom. Student responses to the survey indicated students "generally felt that the activities had a positive effect on their ability to learn the course material" (Wilson, 2013, p. 106).

The Flipped Learning Network reported from a survey of 453 teachers that there was a 67% increase on test scores and an 80% improvement in student attitudes (Flipped Learning Network, 2012). Alvarez (2011), reporting about the flipped classroom study in Clintondale High School, stated that failure rates decreased from 52 to 19 percent in English language arts, from 44 to 13 percent in math, from 41 to 19 percent in science, and from 33 to less than 10 percent in social studies. There was also a decrease in discipline from 735 to 249 reports. At the Byron School District, Fulton (2012) stated that there was a math proficiency increase by 9.8% in calculus and 6.1% in pre-calculus. Byron High School also experienced an increase in MCA math mastery levels from 29.9% in 2006 to 73.8% in 2011.

In the last few years, there have been a number of studies in which results have not shown a significant improvement. Davies, in studying a post-secondary level spreadsheet course, compared pre-test and post-test data of three different classroom types: traditional, flipped, and online. There was not statistical difference between the three types on the tests; however, the end of semester grades showed some statistical difference between the online course and the other two. The overall grades for the flipped and traditional classrooms were higher than the online classroom but not significantly different from each other (Davies, 2013).

Lavelle (2013) conducted a post-secondary study in an engineering economics class and found no significant difference in the course evaluation analysis, and grade analysis. He also

found no significant relationship between actual view habits [of the online videos] and student's final grade.

Glynn (2013), who conducted a study in a secondary chemistry classroom, reported from a survey that 59% of students felt that the flipped classroom helped them learn chemistry more efficiently to some degree although some reported they wished they could review what was covered the night before. In the same study, 42% of the students receiving grades in the top half of the class reported benefits from the flipped classroom while only 30% of bottom half reported a benefit. The students' attitude toward chemistry dropped from 3.89 to 3.44 (on a 5 point scale) after experiencing the flipped classroom, although Glynn stated that could be from the increased difficulty of the course. Overall though, 59% of the students preferred the traditional classroom versus the flipped classroom. Scores in the flipped classroom were slightly higher but there was not a significant difference.

Strayer compared an inverted and traditional style post-secondary introductory statistics course. In his inverted classroom, he used ALEKS to deliver basic course content instead of recording lectures. His students felt that the learning environment did not measure up to their preferred traditional environment. The students never really settled into "how to do class" yet the students did feel that the inverted classroom did improve cooperative learning (Strayer, 2012).

Many of the literature sources above showed a lack of academic improvement. Does that mean that flipped classrooms are not a good option? In 1998, Marzano conducted a meta-analysis of research in effective strategies in instruction. He published his findings in a 2002 edition of the book *Classroom Instruction That Works: Research-Based Strategies for Increasing Student Achievement.* In the 2nd edition, published in 2012, nine strategies for effective classrooms were listed. Perhaps it should be examined if whether flipped classrooms could

actually be the tool for allowing instructors to utilize these effective strategies in their classrooms. The next section will examine if flipped classrooms can use these strategies.

Can a Flipped Classroom be an Effective Classroom?

The nine effective strategies of *Classroom Instruction that Works* are (Dean et al, 2012):

- Setting and communicating learning objectives and providing feedback
- Reinforcing effort and providing recognition
- Classrooms that use cooperative learning
- Instructors that use cues, questions and advance organizers
- Instruction that utilizes nonlinguistic representations
- Students that use summarizing and note taking skills
- Instructors that assign useful homework and provide practice
- Instructors that help student identify similarities and differences
- Instructors that allow students to generate and test hypotheses

Just as an instructor should inform their students at the beginning of a lecture of what the objectives for the lesson are, the objectives for a lesson in a flipped classroom can be communicated in several ways. Objectives can be communicated directly to the student through the video lecture, through notes, and through the online site for that lesson. In a *flipped mastery classroom*, students have to prove that they have completed the objectives for that lesson before they are allowed to move on. Forsey (2013) described how students increased their learning time because they had a clear layout of material and the structure led the student to a sense of accomplishment when their tasks were completed.

One of the advantages listed earlier was increased student-teacher and student-student interaction. This allows instructors to provide quicker feedback to students with questions and for students to get feedback from their peers.

Reinforcing effort and providing recognition can be accomplished in a flipped classroom because of the increased teacher-student interaction. Earlier in this paper, it was shown that

there was a lot of positive feedback from students about their motivation in the flipped classroom design. In Kim's (2014) study, students felt that their contributions were acknowledged by others and they learned to regulate their own learning with the help of peers and evaluated their own achievements. The Flipped Learning Network's (2012) survey also showed an 80% improvement on student attitudes.

In an inverted classroom, the lecture is watched away from the classroom. This opens up time in which an instructor can add other activities such as cooperative learning, generating and testing hypothesis, use cues, questions, and advance organizers, and identify similarities and differences. Also, during the lecture, now done at home, students are doing useful homework, summarizing and note taking, and could utilize nonlinguistic representations. If students are trained properly on these activities at the beginning of their class, these seven effective practices will now be incorporated into the classroom.

Conclusions from Literature Review on Flipped Classrooms

In conclusion, the literature showed very little statistically significant data for positive academic outcomes when using a flipped classroom. It did show some promising survey results however and did show how the nine effective strategies from Marzano's research could be effectively incorporated into the flipped classroom. Perhaps the question should not be whether a flipped classroom is effective. Maybe the question should be, is the flipped classroom effectively using the strategies from Marzano.

Literature Review on Learning Styles

Like flipped classrooms, learning styles is another highly debated and hot topic in education today. Some have suggested that utilizing learning styles in the classroom could be

harmful to a student because it “limits” them (Scott, 2010). As a result of a meta-analysis study conducted by Hattie in 2009, Hattie and Yates write:

> "We are all visual learners, and we all are auditory learners, not just some of us. Laboratory studies reveal that we all learn when the inputs we experience are multi-modal or conveyed through different media…Claims such that 'some students learn from words, but others from images' are incorrect, as all students learn most effectively through linking images with words. These effects become especially strong when the words and images are made meaningful through accessing prior knowledge. Differences between students in learning are determined strongly by their prior knowledge, by the patterns they can recognize, and not by their learning style" (Hattie and Yates, 2014)

Hattie and Yates are not saying that students cannot communicate their preferred learning styles but “what individuals say about how they learn does not actually predict how they learn any more than statements that are valid for virtually everyone.” Also, the theory that the learner learns more effectively when the instructions style matches their learning style is not supported by research. It has “never been demonstrated to exist, and is counter-indicated by scores of studies into effective teaching strategies” (Hattie and Yates, 2014). However, learning styles can still be utilized in insuring that all types of learning styles are being addressed in the classroom. Similarly in referring to multiple intelligences, Howard Gardner states multiple intelligences can aid educators “about how to individualize and how to pluralize. As my colleague Mindy Kornhaber once quipped, ‘MI theory is a closet organizer. It helps teachers organize their practices and see what is missing’” (Gardner, 2011). Keeping this in mind, the purpose of this section is to explore a few of the more popular types of learning styles that are present within the literature that we can use to make sure that we, as educators, are utilizing all of the learning styles in our preferred model in designing instruction.

The theory that people could possess eight or more relatively autonomous multiple intelligences was developed by Howard Gardner in the early 1980’s. “An intelligence is a biopsychological potential to process information in certain kinds of ways, in order to solve

problems or create products that are valued in one or more cultural settings" (Gardner, 2011). In a speech he gave in 2011, he continued on to say:

> "The original seven were linguistic, logical-mathematical, musical, spatial, bodily kinesthetic, interpersonal and intrapersonal. Some years ago I added an eighth or naturalist intelligence. And I now think that sooner or later there might be an existential intelligence—the intelligence that leads human beings to pose big 'existential questions' and a pedagogical intelligence, the intelligence that enables human beings to convey knowledge and skills to other human beings who have varying degrees of knowledge. Those, then, are the multiple intelligences, circa 2011."

Gardner believes that just because we know the strength of one intelligence, does not mean we know if another intelligence is strong or weak. For example, commonly, some people may say that they sense they are good at English (linguistic), but they are not good at math. Knowing that they are good at English does not predetermine that they will be bad at math. It just means that they are good at English. The other most educational implication of multiple intelligence theory can be best stated in two words: individualization and pluralization. In individualization Gardner states:

> "Human beings differ from one another and there is absolutely no reason to teach and assess all individuals in the identical way. Rather, in the future, good practice should particularize the modes of presentation as well as the manner of assessment as much as feasible; and that individuation should be based on our understanding of the intellectual profiles of individual learners." (Gardner, 2011)

He later states that with pluralization, students should be taught in multiple ways, activating multiple intelligences. In a paper he co-authored in 2012, he wrote that modern schools are typically activating only two: linguistic and logical-mathematical. Gardner also believes that because one person is not born with a high intelligence in math, does not mean he/she cannot succeed at math. It will mean that their path to success will happen differently than a person who has a strong intelligence in math (Davis et al, 2012).

A commonly referred to learning style model, VARK, was developed by Fleming and Mills in 1992. Fleming and Mills agreed with the premise that students have preferred learning styles, but felt that it was too cumbersome for educators to instruct in every model of learning style defined (keep in mind there are many). "We have come to the conclusion that the most realistic approach to the accommodation of learning styles in teaching programs should involve empowering students through knowledge of their own learning styles to adjust their learning behavior to the learning programs they encounter" (Fleming and Mills, 1992). In questioning students, they found that students related more easily to the senses that were used to teach the information in picking their preferred learning style. "Although we started with Stirling's (1987) three categories of visual, aural, and kinesthetic, we found that the categories appeared to be insufficient to account for the more detailed differences we noted among students."

The VARK model can best be described by the following categories. Visual (V) is the preference to learn by what the student can see; i.e. graphical and symbolic ways of representing information. Aural (A) is the preference students have to learn by hearing. These students prefer to learn in traditional lecture formats or by listening and discussion with others. Read/Write (R) is the preference to learn by reading. The last preference is learning through kinesthetic (K) activity. With this preference, students prefer experience, labs, and hands-on method of learning.

The Felder-Silverman Index of Learning Styles is more of measurement along four different dimensions, yet can be anywhere along the dimensions. The first dimension is *sensing or intuitive.* Sensing style learners are people who like concrete thinking, practical and are oriented toward facts and procedures. Where intuitive learners are more abstract thinkers, more innovative, and are oriented toward theories and underlying meanings. The second dimension is *visual or verbal.* The visual learner prefers visual representations like diagrams, maps, graphs

and flowcharts where the verbal learner prefers written and spoken explanations. The third dimension is *active or reflective.* Active style learners try things out and enjoy working in groups. Reflective style learners prefer to learn through thinking and working alone. The last dimension is *sequential or global.* The sequential learner prefers thinking through a process in order and in small steps. The global learner likes learning with the "big picture" or holistic thinking process (Felder, 2005).

The last learning style model to be studied in this section is Kolb's Experiential Learning Model. This model is a learning style that is not fixed and it moves along two axes; the concrete experience vs abstract conceptualization axis and the active experimentation vs the reflective observation axis. This model has 9 different learning styles represented and can be examined in Figure 1.

CONCRETE EXPERIENCE

NW Feeling-Acting Accommodating	N Feeling Acting-Reflecting Northerner	NE Feeling-Reflecting Diverging
W Acting Feeling-Thinking Westerner	C Feeling Acting + Reflecting Thinking Balancing	E Reflecting Feeling-Thinking Easterner
SW Thinking-Acting Converging	S Thinking Acting-Reflecting Southerner	SE Thinking-Reflecting Assimilating

ACTIVE EXPERIMENTATION — **REFLECTIVE OBSERVATION**

ABSTRACT CONCEPTUALIZATION

Figure 1 (Kolb, 2005)

Chapter 3 Methodology

Summary of Experiment

An experiment was conducted to answer the last two research questions which are:

4. Is a student with a certain learning style, based on the VARK Learning Style Inventory, more likely to score higher in formative and summative assessments than students in a non-flipped classroom?
5. Is a student with a certain learning style, based on the VARK Learning Style Inventory, more likely to be more motivated in a flipped classroom vs motivation of students in a non-flipped classroom?

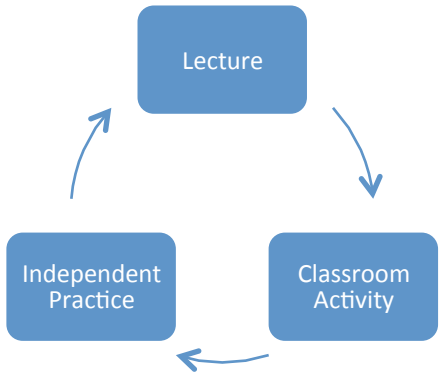
To investigate question 4, a second 2x4x2 factor experimental design study was conducted. In the first study, the independent variables in the study were based on two variations of factor one: flipped and traditional, and the four types of learning styles. The four types of learning styles are defined by the VARK Learning Style: visual, audial, reading/writing and kinesthetic. Each student enrolled in all four sections were given the VARK learning style inventory for this data. The dependent variable was the average test scores from all of the summative unit tests at the end of quarter one.

To investigate question 5, a combined quantitative/qualitative study was conducted utilizing a 2x4x2 factor experimental design. The independent variables are the same as the experiment above with flipped/traditional and the four variations of learning styles as defined the VARK Learning Style: visual, audial, reading/writing and kinesthetic. The dependent variable was motivated/ not motivated as determined by a survey, based on the literature review, and administered to all of the students. To protect the validity of the outcomes, both the flipped classroom and the traditional classroom will receive the exact same instruction, but in different

order. See the setting section below for more information about how the classroom will be set up.

Setting and Population

The study took place in four of my College Algebra Prep classes being taught at a large urban high school during the 1st quarter of the 2014-2015 school year. Two of the classes were flipped while the other two remained traditional. The three basic components of my classroom can be described by the following diagram:



All of my classes will receive the exact same components, just in different order. The two traditional classrooms contained the lecture and classroom activity portion of the class during the 55 minute time while the independent practice portion was completed as student homework. The flipped classroom contained the classroom activity and independent practice portions while the lecture portion was done at home as homework.

The high school requires all seniors to take a 4th year of math even though it is not required to graduate. Therefore, the students in this study are predominately two types: those

who can but do not want to take pre-calculus or those who are not prepared to take a pre-calculus class. Those who do not want to take pre-calculus have various reasons including the following:

- They are not planning on majoring in a math or science related field.
- They just want to keep practicing math their senior year, but do not need the math credits to graduate
- They are already overwhelmed by a strong class load with several other AP or college level classes.

The students who cannot take pre-calculus are those who:

- Have a history of struggling in math and are behind
- Have an IEP and are not prepared for Pre-calculus
- A handful of juniors who do not feel that their algebra skills are good enough to go on to pre-calculus this year but hope to go on to it next year.

There are a total of 6 College Algebra Prep classes being offered at the high school, with about 30-32 students in each class. There will be about 120 students, 60 each in flipped and traditional structured classrooms. The counseling office has reported that students are placed in courses relatively randomly as there are plenty of sections of each core course and students' schedules are typically not limited.

Data Collection

A VARK Learning Style Inventory was given to each student in all four sections during the first few days of class. This was given through a link pushed to each of the students through Moodle.

A pre-test and post-test score for each unit was kept for each student in the first unit. The units covered in 1st quarter were Set Theory and Logic. The second unit did not have a pre-test as students had not encountered logic in previous math courses at Edina High School. Scores are kept in TIES, a school administration software and can be downloaded into excel where statistical analysis of the data was performed.

A motivation survey (shown below) was collected through google forms. It was downloaded and analyzed in Excel.

Student Experience Questionnaire

Thank you for completing this survey. The first column of this survey is to find the degree of your motivation during this last period of study. The second column is to examine your opinion of the value of teaching during this period of study.

Statement	How often do I do this? 1(often) 2 3 4 5(not often)	How important is this to me? 1(often) 2 3 4 5(not often)
I watched the online videos.		
I took notes.		
I completed my independent work.		
I helped my team during the group activity.		
I received helpful		

feedback.		
I asked for help from Mrs. Seaver.		

Confidentiality

All student data had their names removed to make sure of anonymity in all data reports. Students will also have parents sign a consent form allowing their data to be used for this study.

Hypotheses:

Null Hypothesis1:

The mean post- test scores of students enrolled in the flipped classroom will not be significantly different than the mean post-test scores of the students enrolled in the traditional classroom.

H_{o1}: $\mu_{flipped} = \mu_{traditional}$

Alternative Hypothesis 1:

The mean post- test scores of students enrolled in the flipped classroom will be significantly greater than the mean post-test scores of the students enrolled in the traditional classroom.

H_{o1}: $\mu_{flipped} > \mu_{traditional}$

Null Hypothesis 2:

The mean post-test scores of students in the flipped classroom of each learning style will not be significantly different than the mean post-test scores of the students with like learning styles enrolled in the traditional classroom.

H_{o2}: $\mu_{flipped} = \mu_{traditional}$

Alternative Hypothesis 2:

The mean post-test scores of students in the flipped classroom of each learning style will be significantly greater than the mean post-test scores of the students with like learning styles enrolled in the traditional classroom.

H_{o2}: $\mu_{flipped} > \mu_{traditional}$

Null Hypothesis 3:

The mean motivation scores of students in the flipped classroom will not be significantly different than the mean motivation scores of the students enrolled in the traditional classroom.

H_{o3}: $\mu_{flipped} = \mu_{traditional}$

Alternative Hypothesis 3:

The mean motivation scores of students in the flipped classroom will be significantly greater than the mean motivation scores of the students enrolled in the traditional classroom.

H_{o3}: $\mu_{flipped} > \mu_{traditional}$

Null Hypothesis 4:

The mean motivation scores of students in the flipped classroom of each learning style will not be significantly different than the mean motivation scores of the students with like learning styles enrolled in the traditional classroom.

H_{o3}: $\mu_{flipped} = \mu_{traditional}$

Alternative Hypothesis 4:

The mean motivation scores of students in each learning style will be significantly greater than the mean motivation scores of the students with like learning styles enrolled in the traditional classroom.

H_{o4}: $\mu_{flipped} > \mu_{traditional}$

Assumptions

All students enrolled in College Algebra Prep have passed all their algebra and geometry prerequisites to this class. There will be some variance within the classroom based on individual students and their attitudes, efforts, and abilities. In many classrooms, academic dishonesty is an issue. An assumption is that students are being honest and ethical in their test completion and coursework and teachers do their best to design against cheating. Lastly, it is assumed that students are being randomly placed in the four section of College Algebra Prep being used for this study. The counseling office has stated that this is the case. Ethical treatment and confidentiality of all the students will be maintained.

Limitations of Study

Students were assigned to the classroom based on scheduling. It is assumed that some classes are not impacted by a certain type of student (i.e. choir), and that students did not have to take the class during a certain period. Because of the size of the school and the number of classes being offered, the counseling office has stated with confidence that most of the students are placed randomly within the 6 sections of CAP. The research has been done at large urban high school because that is where I work and the classes in the research are chosen based on convenience as I teach the 4 section of CAP. Not all students watched all the videos or completed the homework. Many students in this course have a tendency to finish it with as little effort as possible. Students will be encouraged to do the work however and be monitored for class credit.

Delimitations

The definition of learning styles will be limited to those that are defined in the VARK learning style inventory. This inventory was free to use and was limited to four main outcomes.

Definition of Terms

VARK – A learning style inventory that measures students learning styles based on visual, auditory, reading/writing, and kinesthetic.

Flipped Classroom – in this study is purely an "inverted classroom," one in which the lectures are watched at home and labs and coursework occur during class-time.

CAP – College Algebra Prep – the course that this study is taking place in.

TIES – a school administration software, where attendance, grades and other student records are maintained

Moodle – a open source learning management software that allows teachers to post online resources and monitor activity.

Chapter 4: Results

Flipped vs Traditional Overall Results

All the data for the first hypothesis is found in Appendix A. The following two tables are the t-tests that compared the flipped data vs the traditional data:

Set Theory Unit Results:

t-Test: Two-Sample Assuming Equal Variances

	Flipped	*Traditional*
Mean	78.42243	80.28846
Variance	138.6602	114.5039
Observations	59	60
Pooled Variance	126.4788	
Hypothesized Mean Difference	0	
df	117	
t Stat	-0.90498	
P(T<=t) one-tail	0.183668	
t Critical one-tail	1.657982	
P(T<=t) two-tail	0.367335	
t Critical two-tail	1.980448	

Logic Unit Results:

t-Test: Two-Sample Assuming Unequal Variances

	Flipped	*Traditional*
Mean	73.6538462	72.5614
Variance	247.250377	211.8221
Observations	52	57
Hypothesized Mean Difference	0	
df	104	
t Stat	0.37534577	
P(T<=t) one-tail	0.35408388	
t Critical one-tail	1.65963744	
P(T<=t) two-tail	0.70816776	
t Critical two-tail	1.98303753	

Learning Styles in Flipped Vs. Traditional Results

All the data for the first hypothesis is found in Appendix B. The following two tables are the t- tests that compared the flipped data vs the traditional data for two different curriculum units studied in class; Set Theory and Logic.

Visual

t-Test: Two-Sample Assuming Unequal Variances

	Set Theory Unit ***Traditional***	*Set Theory* ***Flipped***
Mean	79.1153846	74.65035
Variance	155.543269	132.0771
Observations	9	11
Hypothesized Mean Difference	0	
df	17	
t Stat	0.8250271	
P(T<=t) one-tail	0.21039144	
t Critical one-tail	1.73960673	
P(T<=t) two-tail	0.42078288	
t Critical two-tail	2.10981558	

t-Test: Two-Sample Assuming Unequal Variances

	Logic Unit ***Traditional***	*Logic Unit* ***Flipped***
Mean	78.55555556	70.36364
Variance	155.2777778	348.4545
Observations	9	11
Hypothesized Mean Difference	0	
df	17	
t Stat	1.171101734	
P(T<=t) one-tail	0.128855924	
t Critical one-tail	1.739606726	
P(T<=t) two-tail	0.257711848	
t Critical two-tail	2.109815578	

Auditory

t-Test: Two-Sample Assuming Unequal Variances

	Set Theory Unit ***Traditional***	*Set Theory* ***Flipped***
Mean	81.85664336	83.17308
Variance	97.38548631	64.54114
Observations	22	14
Hypothesized Mean Difference	0	
df	32	
t Stat	-0.43791937	

t-Test: Two-Sample Assuming Unequal Variances

	Logic Unit ***Traditional***	*Logic Unit* ***Flipped***
Mean	78.45454545	75
Variance	175.1168831	201.6923
Observations	22	14
Hypothesized Mean Difference	0	
df	26	
t Stat	0.730453149	

P(T<=t) one-tail	0.332193301	P(T<=t) one-tail	0.235822256
t Critical one-tail	1.693888748	t Critical one-tail	1.70561792
P(T<=t) two-tail	0.664386603	P(T<=t) two-tail	0.471644513
t Critical two-tail	2.036933343	t Critical two-tail	2.055529439

Read/Write

t-Test: Two-Sample Assuming Unequal Variances

	Set Theory Unit ***Traditional***	*Set Theory Unit* ***Flipped***
Mean	81.5604396	78.84615
Variance	154.331979	203.8646
Observations	14	17
Hypothesized Mean Difference	0	
df	29	
t Stat	0.565774	
P(T<=t) one-tail	0.28794971	
t Critical one-tail	1.69912703	
P(T<=t) two-tail	0.57589941	
t Critical two-tail	2.04522964	

t-Test: Two-Sample Assuming Unequal Variances

	Logic Unit ***Traditional***	*Logic Unit* ***Flipped***
Mean	78	80.71429
Variance	153.1666667	164.8352
Observations	13	14
Hypothesized Mean Difference	0	
df	25	
t Stat	-0.55924855	
P(T<=t) one-tail	0.290484052	
t Critical one-tail	1.708140761	
P(T<=t) two-tail	0.580968105	
t Critical two-tail	2.059538553	

Kinesthetic

t-Test: Two-Sample Assuming Unequal Variances

	Set Theory Unit ***Traditional***	*Set Theory Unit* ***Flipped***
Mean	80.17241379	76.08696
Variance	84.95441892	122.7394
Observations	29	23
Hypothesized Mean Difference	0	
df	43	
t Stat	1.420999941	
P(T<=t) one-tail	0.081264252	
t Critical one-tail	1.681070703	

t-Test: Two-Sample Assuming Unequal Variances

	Logic Unit ***Traditional***	*Logic Unit* ***Flipped***
Mean	72.5555556	69
Variance	195.794872	296.7368
Observations	27	20
Hypothesized Mean Difference	0	
df	36	
t Stat	0.7565268	
P(T<=t) one-tail	0.22712805	
t Critical one-tail	1.68829771	

P(T<=t) two-tail	0.162528505	P(T<=t) two-tail	0.4542561
t Critical two-tail	2.016692199	t Critical two-tail	2.028094

Motivation in Flipped Vs Traditional

All the data for the first hypothesis is found in Appendix C. The following three tables are the t-tests that compared the flipped data vs the traditional data for each of the three surveys.

Survey 1

t-Test: Two-Sample Assuming Equal Variances

	Trad	*Flip*
Mean	4.188	4.426
Variance	1.008	0.727
Observations	69.000	188.000
Pooled Variance	0.802	
Hypothesized Mean Difference	0.000	
df	255.000	
t Stat	-1.881	
P(T<=t) one-tail	0.031	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.061	
t Critical two-tail	1.969	

Survey 2

t-Test: Two-Sample Assuming Equal Variances

	Trad	*Flip*
Mean	4.177	4.329
Variance	0.982	0.919
Observations	147.000	216.000
Pooled Variance	0.945	
Hypothesized Mean Difference	0.000	
df	361.000	
t Stat	-1.461	
P(T<=t) one-tail	0.072	
t Critical one-tail	1.649	
P(T<=t) two-tail	0.145	
t Critical two-tail	1.967	

Survey 3

t-Test: Two-Sample Assuming Equal Variances

	Trad	*Flip*
Mean	3.939	4.114
Variance	1.596	1.313
Observations	66.000	176.000
Pooled Variance	1.390	
Hypothesized Mean Difference	0.000	
df	240.000	
t Stat	-1.024	
P(T<=t) one-tail	0.153	
t Critical one-tail	1.651	
P(T<=t) two-tail	0.307	
t Critical two-tail	1.970	

Motivation within Learning Style in Flipped Vs Traditional

All the data for the first hypothesis is found in Appendix D. The following two tables are the t-tests that compared the flipped data vs the traditional data:

Visual

t-Test: Two-Sample Assuming Unequal Variances

	Traditional	*Flipped*
Mean	3.956481	3.756666667
Variance	0.029198	0.8955
Observations	9	5
Hypothesized Mean Difference	0	
df	4	
t Stat	0.467931	
P(T<=t) one-tail	0.332096	
t Critical one-tail	2.131847	
P(T<=t) two-tail	0.664192	
t Critical two-tail	2.776445	

Auditory

t-Test: Two-Sample Assuming Unequal Variances

	Traditional	*Flipped*
Mean	3.860938	4.072619
Variance	0.241479	0.184342
Observations	16	14
Hypothesized Mean Difference	0	
df	28	
t Stat	-1.25921	
P(T<=t) one-tail	0.109175	

t Critical one-tail	1.701131
P(T<=t) two-tail	0.21835
t Critical two-tail	2.048407

Read/Write

t-Test: Two-Sample Assuming Unequal Variances

	Traditional	*Flipped*
Mean	3.865278	4.102083
Variance	0.175427	0.354144
Observations	12	16
Hypothesized Mean Difference	0	
df	26	
t Stat	-1.23522	
P(T<=t) one-tail	0.113896	
t Critical one-tail	1.705618	
P(T<=t) two-tail	0.227793	
t Critical two-tail	2.055529	

Kinesthetic

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	3.776812	3.794697
Variance	0.256755	0.201968
Observations	23	22
Hypothesized Mean Difference	0	
df	43	
t Stat	-0.1254	
P(T<=t) one-tail	0.450397	

t Critical one-tail	1.681071
P(T<=t) two-tail	0.900794
t Critical two-tail	2.016692

Data Collection Issues

The number of responses on the motivation surveys were low. Interestingly, it seems my students were not motivated to respond to the motivation surveys. Also, one question "Did you ask Mrs. Seaver for help?" scale was backwards compared to the rest of the questions. As a result, I threw the question out and based motivation on the other 4 questions. Also, I did not count the question on whether the students watched the videos in the traditional style setting because they were not required to watch them.

Chapter 5: Conclusions

Discussion of Hypothesis 1: Traditional vs Flipped test outcomes

Excel was used to calculate the two-sample t test on the Set Theory Unit data and the resulting p-value was 0.184. Excel also gave a p-value of 0.35 on the Logic Unit. Based on the p-values for each of these hypothesis tests and setting the alpha level at 0.05, the conclusion is that the data supports the null hypothesis. The flipped learning structure is not an improvement over the traditional style classroom.

Discussion of Hypothesis 2: Learning Style on test results in Traditional vs Flipped

Visual

A two-sample t-test on Excel comparing the means for the set theory test in the traditional versus flipped classrooms for visual learning style students produced a p-value of 0.21. Excel also gave a p-value of 0.129 for the Logic Unit. Neither test's p-values were less than 0.05. Therefore, the null hypothesis stands that there is no significant difference in scores between traditional and flipped classrooms for the visual learner.

Auditory

A two-sample t-test on Excel comparing the means for the set theory test in the traditional versus flipped classrooms for auditory learning style students produced a p-value of 0.332. This same test for the logic unit produced a p-value of 0.335. Neither test's p-values were less than 0.05. Therefore, the null hypothesis stands that there is no significant difference in scores between traditional and flipped classrooms for the auditory learner.

Read/Write

A two-sample t-test on Excel comparing the means for the set theory test in the traditional versus flipped classrooms for Read/Write learning style students produced a p-value of 0.288. This same test for the logic unit produced a p-value of 0.290. Neither test's p-values were less than 0.05. Therefore, the null hypothesis stands that there is no significant difference in scores between traditional and flipped classrooms for the read/write learner.

Kinesthetic

A two-sample t-test on Excel comparing the means for the set theory test in the traditional versus flipped classrooms for Kinesthetic learning style students produced a p-value of 0.081. This same t-test for the logic unit produced a p-value of 0.227. Neither test's p-values were less than 0.05. Therefore, the null hypothesis stands that there is no significant difference in scores between traditional and flipped classrooms for the kinesthetic learner.

Overall, we can conclude that because no type of learning style had a significant difference in test scores between the traditional and flipped classroom, that learning style as determined by VARK makes no significant difference in how well a student learns in either classroom setting.

Discussion of Hypothesis 3: Traditional vs Flipped Motivation

The mean on the motivation surveys show a slightly higher value for the flipped class setting versus the traditional class setting over all three surveys. After using Excel to calculate the two-sample t-test, the p value for the first survey is 0.031, which is less than 0.05. However, the data for survey 2 and 3 have p-values of 0.145 and 0.307 respectively, which are greater than 0.05. Therefore, in the timeframe of the first survey, the null hypothesis can be rejected for the

alternative hypothesis stating that flipped classrooms can encourage motivation. For the 2nd and 3rd surveys the null hypothesis would stand.

Discussion of Hypothesis 4: Learning style and motivation in Traditional vs Flipped

Visual

The t-test on Excel comparing the means for the motivation surveys in the traditional versus flipped classrooms produced a p-value of 0.332 . The test's p-value is more than 0.05. Therefore, the null hypothesis stands that there is no significant difference in motivation between traditional and flipped classrooms for the visual learner.

Auditory

The t-test on Excel comparing the means for the motivation surveys in the traditional versus flipped classrooms produced a p-value of 0.109 . The test's p-value is more than 0.05. Therefore, the null hypothesis stands that there is no significant difference in scores between traditional and flipped classrooms for the auditory learner.

Read/Write

The t-test on Excel comparing the means for the motivation surveys in the traditional versus flipped classrooms produced a p-value of 0.114. The test's p-value is more than 0.05. Therefore, the null hypothesis stands that there is no significant difference in scores between traditional and flipped classrooms for the read/write learner.

Kinesthetic

The t-test on Excel comparing the means for the motivation surveys in the traditional versus flipped classrooms produced a p-value of 0.45. The test's p-value is more than 0.05.

Therefore, the null hypothesis stands that there is no significant difference in scores between traditional and flipped classrooms for the kinesthetic learner.

Overall, we can conclude that because no type of learning style had a significant difference for motivation between the traditional and flipped classroom, that learning style as determined by VARK makes no significant difference in how much a student is motivated when comparing either classroom setting.

Additional Research Questions

- Did the middle school experience of the flipped classroom affect some of the students motivation?
- Would a different type of learning style inventory make a difference on the outcomes?
- Would a longer time period of data collection change the overall trend of there being no benefit test-wise to students?

Summary and Conclusion

The outcomes of this study were a surprise to me. I had hoped that the data would show that students benefited from flipped classrooms in both assessment data and motivation data. After reading the literature, I had assumed that an improvement would show because I had more time to work with students in a smaller group setting and that students were gaining more hands-on activity time. Perhaps the fact that there was no significant difference between the different learning styles may indicate that all learning styles were being satisfied in both the flipped classroom and the traditional classroom.

Based on this study, I can conclude that while the flipped classroom does not improve student achievement, it does not harm it either. This means that teachers have room to choose whichever method of teaching they most like as either setting can be successful.

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Appendix A : Data for Hypothesis 1

Set Theory Unit

Flipped	Traditional
41.35	56.73
53.85	59.62
60.58	62.50
61.54	66.35
66.35	67.31
67.31	69.23
70.19	69.23
72.12	72.12
72.12	72.12
73.08	72.12
74.04	73.08
78.85	74.04
78.85	76.92
80.77	77.88
82.69	78.85
82.69	79.81
82.69	80.77
82.69	82.69
83.65	84.62
86.54	84.62
86.54	85.58
86.54	86.54
87.50	87.50
87.50	89.42
87.50	89.42
90.38	90.38
91.35	90.38
96.15	91.35
96.15	92.31
100.00	95.19
57.69	95.19
59.62	57.69
62.50	63.46
63.46	65.38
66.35	66.35
68.27	68.27
68.27	72.12
69.23	74.04

70.19	74.04
73.08	76.92
75.96	78.85
75.96	79.81
77.88	79.81
77.88	79.81
80.77	80.77
81.73	82.69
81.73	83.65
82.69	84.62
83.65	85.58
84.62	85.58
85.58	85.58
85.58	87.50
87.50	88.46
88.46	90.38
90.38	91.35
91.35	92.31
91.35	92.31
91.35	96.15
92.31	100.00
	100.00

Logic Unit

Flipped	**Traditional**
100	90
75	90
53	58
92	81
68	56
92	81
74	71
67	82
85	79
51	89
97	63
99	90
75	78
57	92
74	92
89	72

89	68
53	46
85	71
51	90
78	82
61	78
81	60
58	61
79	64
40	56
50	38
90	71
74	86
78	43
79	64
63	88
82	56
76	85
82	76
54	61
86	96
86	82
57	78
83	65
82	85
61	85
86	88
81	88
82	44
96	74
39	58
75	61
79	72
69	67
75	54
42	56
	89
	81
	82
	69
	54

Appedix B: Data for Hypothesis 2

Visual

Traditional

Learning Style Results	Set Theory Unit	Logic Unit
VA	72	71
VA	72	63
VA	69	90
VA	90	96
VK	72	81
VK	92	65
VK	100	88
VR	63	66
VR	81	87

Flipped

Learning Style Results	Set Theory Unit	Logic Unit
V	88	100
V	62	54
V	72	71
V	82	87
V	68	51
V	82	71
VA	66	62
VK	54	44
VK	88	74
VK	73	61
VR	87	99

Auditory

Traditional

Learning Style Results	Set Theory Unit	Logic Unit
A	69	90
A	92	84
A	72	63
A	83	85
A	96	96
A	66	47
A	65	59
A	90	74
A	86	67
A	78	65
A	89	78
A	95	81
AK	88	78
AK	86	82
AR	85	90
AR	87	90
AR	92	89
VA	72	71
VA	72	63
VA	69	90
VA	90	96
AK	78	
AK		88

Flipped

Learning Style Results	Set Theory Unit	Logic Unit
A	87	99
A	79	57
A	90	81
A	81	78
A	84	87
A	92	81
A	91	88
A	91	79
AK	91	88
AK	73	60

AK	76	78
AK	85	59
VA	66	62
A	78	
AK		53

Read/Write

Traditional

Learning Style Results	Set Theory Unit	Logic Unit
		90
AR	85	
AR	87	90
AR	92	89
R	77	82
R	66	75
R	57	56
R	83	
R	91	82
R	80	65
R	86	59
R	100	85
RK	95	88
VR	63	66
VR	81	87

Flipped

Learning Style Results	Set Theory Unit	Logic Unit
R	96	
R	84	71
R	83	
R	83	94
R	83	79
R	41	90
R	72	54
R	100	
R	67	59
R	70	74
R	63	79
R	90	88

R	86	82
R	78	82
RK	66	91
RK	91	88
VR	87	99

Kinesthetic

Traditional

Learning Style Results	Set Theory Unit	Logic Unit
AK	78	
AK	88	78
AK	86	82
AK		88
K	67	79
K	86	91
K	80	69
K	60	82
K	81	90
K	89	94
K	73	65
K	90	78
K	85	
K	79	51
K	74	44
K	74	59
K	80	72
K	91	78
K	80	
K	88	62
K	68	49
K	63	59
K	79	64
K	74	54
K	77	88
K	84	78
K	88	71

VK	72	81
VK		
VK	92	65
VK	100	88

Flipped

Learning Style Results	Set Theory Unit	Logic Unit
AK	91	88
AK		53
AK	73	60
AK	76	78
AK	85	59
K	62	
K	81	69
K	83	
K	79	40
K	88	93
K	74	74
K	60	
K	69	
K	58	65
K	76	96
K		41
K	68	71
K	86	57
K	83	78
K	88	
RK	66	91
RK	91	88
VK	54	44
VK	88	74
VK	73	61

Appendix C: Data for Hypothesis 3

Survey 1		**Survey 2**		**Survey 3**	
Survey results Traditional	Survey results Flipped	Survey results Traditional	Survey results Flipped	Survey results Traditional	Survey results Flipped
4	5	5	5	5	5
5	5	5	5	5	5
5	5	5	4	5	5
5	4	4	3	5	4
2	5	5	5	5	5
5	3	5	5	5	3
5	5	5	4	4	4
5	5	5	5	5	5
5	5	5	5	5	5
4	5	5	5	5	2
5	5	5	4	5	5
5	5	5	5	5	5
5	5	4	5	5	5
5	2	5	4	5	3
5	4	5	5	4	5
5	5	5	5	4	5
4	5	4	5	2	4
3	4	5	4	4	2
4	5	5	5	1	5
4	5	4	5	2	5
2	4	5	3	3	2
4	4	5	4	3	2
3	4	5	5	3	5
5	2	2	4	4	5
5	4	5	4	3	4
3	5	5	5	5	5
5	3	2	5	4	5
5	5	3	4	3	5
4	5	4	5	3	5
3	5	5	5	4	5
5	5	3	5	3	5
3	3	4	5	5	4
4	5	3	5	5	4
4	5	5	5	5	5

5	5	5	5	5	5
3	5	4	5	5	5
3	5	4	5	5	2
3	5	4	5	5	5
5	5	4	4	5	5
5	2	4	5	4	5
5	5	5	5	5	4
3	5	4	4	5	2
3	5	3	5	2	5
3	5	4	5	5	4
5	5	3	5	3	2
4	4	2	2	5	5
4	5	2	5	1	5
1	4	4	4	2	1
3	4	3	3	2	2
5	5	3	4	3	5
5	4	5	2	3	5
5	5	3	5	4	2
4	4	4	4	5	5
5	4	4	5	2	3
5	5	4	5	5	5
3	4	5	5	5	5
5	5	4	5	4	5
5	3	4	5	3	4
5	5	3	3	1	5
4	5	4	2	3	4
4	5	2	5	2	5
3	5	4	5	5	5
5	5	3	5	5	5
5	4	5	5	5	3
2	5	5	5	2	5
4	4	5	5	5	3
5	5	5	3		4
5	5	5	5		3
5	3	3	5		3
	5	4	4		3
	5	3	5		3
	4	5	4		3
	5	5	3		3
	4	2	4		5

4	4	5	2
3	5	5	2
4	5	4	5
5	5	3	2
5	5	2	2
2	5	3	3
5	5	4	4
4	5	5	4
3	5	5	3
4	4	5	5
4	5	4	2
5	5	4	5
5	5	5	4
5	5	1	4
5	5	5	3
5	5	5	5
4	5	4	2
1	5	5	5
5	5	2	5
2	5	3	2
3	5	4	3
5	5	4	5
5	5	5	5
2	4	4	4
3	4	5	3
4	5	4	4
4	4	5	1
3	4	4	4
4	4	5	2
5	3	5	5
5	4	4	5
5	4	3	4
5	5	3	5
5	3	5	4
4	5	4	5
5	4	4	5
5	5	5	5
5	3	4	5
5	5	5	4
5	4	5	5

4	2	5	4
5	5	5	3
5	3	5	5
3	3	5	3
5	2	5	5
5	2	2	3
3	3	2	4
5	4	3	5
5	1	5	4
4	4	5	5
4	5	5	5
5	5	5	5
5	5	3	5
5	5	4	5
5	3	4	5
5	4	4	5
5	5	3	5
5	3	3	4
5	5	3	3
5	5	4	5
4	5	4	2
4	5	5	5
5	5	5	2
4	2	5	5
4	5	5	5
5	4	5	5
5	4	5	4
4	4	4	5
5	5	5	5
5	3	5	5
5	2	5	5
4	4	2	3
4	3	4	4
4		3	5
5		5	3
5		5	3
5		5	5
5		5	2
5		2	5
5		5	4

5	5	5
3	5	5
5	5	5
4	5	4
5	4	2
3	5	5
5	4	5
5	5	5
3	5	1
5	5	4
5	5	5
4	5	5
4	5	5
4	5	5
5	5	3
5	5	5
3	5	5
5	4	5
5	2	5
5	2	3
5	4	4
3	5	5
4	5	
4	5	
5	2	
4	4	
4	4	
5	4	
5	3	
5	3	
5	4	
5	4	
2	4	
3	5	
	5	
	4	
	5	
	5	
	5	
	5	

5
5
5
5
4
1
1
5
5
5
3
5
4
4
5
5
5
4
4
3
5
4

Appendix D: Data for Hypothesis 4

Visual

Traditional

Learning Style Results	Survey 1 avg	Survey 2 avg	Survey 3 avg	Overall Avg
VA	3.75	4		3.88
VR	4.5	4	4.2	4.23
VA		4		4.00
VK	4.25	4.25	4	4.17
VA		3.75		3.75
VA	3.5	4	4	3.83
VR	4			4.00
VA		4		4
VA		3.75		3.75

Flipped

Learning Style Results	Survey 1 avg	Survey 2 avg	Survey 3 avg	Overall Avg
VK	2.6	4	2	2.87
VR	4	5	4.7	4.57
V		2.6		2.60
V	5	4		4.50
VK		4.2	4.3	4.25

Auditory

Traditional

Learning Style Results	Survey 1 avg	Survey 2 avg	Survey 3 avg	Overall Avg
A	3.75	4.5		4.125
A		4.25	4	4.125
A	3.75		3.8	3.775
A		3.25		3.25
AK	3.25	3.75	3.2	3.4
AK		3.75		3.75
AR	3.5	4.5	4.4	4.133333
AR	3.25	3.25		3.25
A		5	4.4	4.7
A		4		4
A		4.25		4.25
A		3		3
A		4.5	4.4	4.45
AK		4.5	4	4.25
AK	4	2.75	3.2	3.316667
AR		4		4
VA	3.75	4		3.875

Flipped

Learning Style Results	Survey 1 avg	Survey 2 avg	Survey 3 avg	Overall Avg
A	4.6	4.2		4.4
A	4.4	4	4.3	4.233333
A	4	4.6	3.8	4.133333
AK	3.2	3.2		3.2
AK	3.4	4.4	4.2	4
AK	4.2			4.2
A	3.6	4		3.8
A	4.4			4.4
A		4.2	4.3	4.25
A	4.2		5	4.6
A	4.6	4.6	4.7	4.633333
A	5	3.4	3.8	4.066667
AK			3.3	3.3
AK	3.8	3.8	3.8	3.8

Read/Write

Traditional

Learning Style Results	Survey 1	Survey 2	Survey 3	Avg
AR	3.5	4.5	4.4	4.133333
AR	3.25	3.25		3.25
R		4.25	4.6	4.425
R		3.25		3.25
R		4		4
R	2.5	3.5	3.8	3.266667
VR	4.5	4	4.2	4.233333
AR		4		4
VR	4			4
R	4.25		4.2	4.225
R	4.25		3.8	4.025
R		3.75	3.4	3.575

Flipped

Learning Style Results	Survey 1	Survey 2	Survey 3	Avg
R	4.2	3.8	4.2	4.066667
R	3.8	4	4.3	4.033333
R			2.5	2.5
R	4.6	5	5	4.866667
R	3.6	3.6	4	3.733333
R	4.8	3.8	4.2	4.266667
R	5	4.8	5	4.933333
R	4	4.4		4.2
R	3	4	4.3	3.766667
VR	4	5	4.7	4.566667
R		3.6		3.6
R	4	4.2		4.1
R	4.2	4.4	4.5	4.366667
R	4.4	4.6	5	4.666667
RK	3.8	3.4		3.6
RK	4.2	4.6	4.3	4.366667

Kinesthetic

Traditional

Learning Style Results	Survey 1	Survey 2	Survey 3	Average
VK	4.25	4.25	4	4.166667
K		3.5		3.5
K		2.25		2.25
K		3.75		3.75
K	4	4	4.4	4.133333
K	3.25	4.25	4.4	3.966667
K		3.75		3.75
K	3.75	3.75		3.75
K	4.5			4.5
AK	3.25	3.75	3.2	3.4
AK		3.75		3.75
AK		4.5	4	4.25
AK	4	2.75	3.2	3.316667
K		3		3
K		3.75		3.75
K	4	3.75	3.6	3.783333
K	4.25		4.6	4.425
K		4		4
K		3.5		3.5
K		4		4
K		4.5		4.5
K		4.25	3.6	3.925
K		3.5		3.5

Flipped

Learning Style Results	Survey 1	Survey 2	Survey 3	Average
VK	2.6	4	2	2.866667
AK	3.2	3.2		3.2
AK	3.4	4.4	4.2	4
AK	4.2			4.2
K	4	4	4	4
K	4.4	4.6	3.8	4.266667
K		4		4
K		3	2.8	2.9
K	4.6	4.4	3.7	4.233333
K	3.8		4.3	4.05
AK			3.3	3.3
AK	3.8	3.8	3.8	3.8
K		3.8		3.8
K	3.8	4.4		4.1
K	3.4			3.4
K	3.2	4.2	4.2	3.866667

K	4	3.75	3.7	3.816667
K			3.3	3.3
K	3.8	4.4	4.3	4.166667
RK	3.8	3.4		3.6
RK	4.2	4.6	4.3	4.366667
VK		4.2	4.3	4.25