# INVESTIGATING THE BENEFITS OF MASTERY LEARNING IN THE HIGH SCHOOL PHYSICS CLASSROOM

by

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# INTRODUCTION AND BACKGROUND

This research was conducted at a major suburban high school in Allen, Texas. This high school sits in the Allen Independent School District, where it acts as the only $10^{th}$ through $12^{th}$ grade high school in the city of Allen, Texas. In the 2015-2016 academic year, Allen High School served 4,743 students across grades 9 through 12. We have two buildings, Allen High School which houses students grades 10 through 12, and Lowery Freshman Center where the ninth graders are housed. Among these students, 13.6% were economically disadvantaged, 2.2% were English language learners and there was a 6.0% mobility rate (Texas Education Agency, 2016.) The median income for Allen, Texas was $101,636 annually, with 68.4% of households making $75,000 annually or more. Students in Allen Independent School District tended to come from middle class to upper middle-class homes. “Over 55% of Allen’s residents have earned a Bachelor’s degree or higher, twice the United States’ average” (Allen Economic Development Committee, 2016).

Students in general education physics classes often struggled with the material presented. Usually, this was because they lack either the science background necessary for upper-level sciences, or they did not possess the necessary math skills for a math-heavy curriculum such as physics. My students had to take physics to fulfill a requirement set up by our school district. Not all students could be successful in the time frame provided by the curriculum calendar. My colleagues and I noticed a shift in the productivity of students when they were being forced to take a class for which they were not prepared. We taught a wide variety of students, ranging in age from 15 to 18. Some students had progressed through their science coursework rapidly and are sophomores when they came to physics, but others were taking physics for a second time, or were behind a year due to remedial science courses.

Some students also received special services such as Special Education, speech therapy, study skills, behavior counseling, and testing accommodations.

Last year, my colleagues and I noticed that we had many students struggling to succeed on the unit tests; we had about a 15% failure rate of students taking “on-level physics” which is what we call general education physics in our school. We were concerned about students growing so far behind in the curriculum that they cannot recover, but also worried about students who just do not have the educational background to find success. The number of assignments marked as missing or given a failing grade seemed too high to us. We had students who we thought could be successful if given a different learning approach. We wondered if this was possibly because of the rigorous pace we set for our students and the curriculum. Teaching general physics in public school was never an easy task, but with our students’ lack of proper math preparation, many of our students struggled with physics. We had to come up with a better way to steer these students through our curriculum. The best way was to allow students to move through the curriculum at their own pace and to require mastery of topics within each unit of the curriculum. We decided to utilize the mastery learning approach.

To tackle this, we spoke to our Instructional Specialist to gather ideas for how to help these students who were struggling due to gaps in their knowledge. She suggested we use the mastery learning approach to better help our students get the time they need to complete our curriculum. This created a starting point from which to build our mastery framework, but also to begin my classroom research project.

The project aimed to combat the negative effects we were seeing in our physics students, while still maintaining academic integrity, student learning and the requirements of the district and state curriculum. By combining self-paced instruction with frequent formative assessments, students could begin to learn where their knowledge gaps are, as well as learn skills for academic success such as time management, self-advocacy, and learning from their mistakes. It should be known that due to constraints of the school in which I was conducting research, this is only an observational study. There was no control group, or treatment group. All students in the study received the same treatment, with no non-treatment units.

My research questions for this project were to evaluate how implementing mastery framework affected student performance in on-level physics classes. In order to measure this, I also had to consider how mastery would impact student performance on common formative assessments, how it impacted student perceptions of physics/science, as well as how mastery encouraged student motivation. Finally, it is also important to see how implementing mastery impacted me, as an educator.

Throughout this project, many people have had a hand as my support team. Ann Crowe was a fellow physics teacher who helped me develop the plan and methodology for mastery learning in my classroom. Ben Wilkinson was another fellow physics teacher who helped build the mastery framework for my class as well as read over several drafts of papers and mastery checks. Cara Johnson was my instructional specialist who was instrumental in pushing me towards implementing mastery, as well as vital in the creation of the capstone and writing process. Annette Terry was my cross-curricular support team member who helped make my “science stuff” paper more readable to a history teacher.

## Research Questions

The guiding research questions for this project were how implementing mastery framework affected student performance in on-level physics classes, how mastery would impact student performance on common formative assessments, how it impacted student perceptions of physics/science, as well as how mastery encouraged student motivation. Finally, it was also important to see how implementing mastery impacted me, as an educator.

## CONCEPTUAL FRAMEWORK

### Rationale for Mastery Learning

Mastery learning approach is the idea that students work through the curriculum at their own pace while "mastering" each concept in a given subject or topic before moving on. In a 1987 article, Robert Slavin described mastery learning as a:

> …large and diverse category of instructional methods. The principal defining characteristic of mastery learning methods is the establishment of a criterion level of performance held to represent 'mastery' of a give skill or concept, frequent assessment of student progress toward the mastery criterion, and provision of corrective instruction to enable students who do not initially meet the mastery criterion to do so on later parallel assessments (p. 175).

"The mastery learning proponent believes that intelligence and aptitude are not the best indicators of potential achievement" but that instead "'cognitive entry characteristics' (specific knowledge, abilities, and skills), which are necessary prerequisites to a particular learning task, are better predictors of later achievement" (Motamedi, 2008, Founders of Mastery Learning section, para. 2). Mastery learning framework is indicative of these traits, and students who can show specific knowledge of topics are better prepared to move on to other topics. By this mindset, you begin to see the reasons why student achievement may benefit from this framework. From Carroll, it is stated that the student "must not only devote the amount of time he needs to the learning task but also that he be allowed enough time for the learning to take place" (Carroll, 1963, p. 7).  This is a direct approach as to why mastery learning should take place in classrooms. Bloom also states that the "task of a strategy for mastery learning is to find ways of alternating the time individual students need for learning as well as to find ways of providing whatever time is needed by each student" (Bloom 1968, p. 7).

Studies for Methodology Framework

The Mastery Learning Manual from Dolan, Ford, Newton and Kellam provides educators with the philosophy, framework, and treatment for implementing mastery learning in the classroom. While this article was tailored for teachers in the elementary grades, much of the information can be altered for high school students as well. The authors say that the most:

> …important thing is to let students know: (1) that this is a mastery class; (2) what mastery learning is and how it works; and (3) that you will be keeping close watch on how well the class does. It will enhance the process if the class develops a real spirit about both individual mastery and that of the whole class (pp. 14-15).

The journal continues to provide framework for helping teachers set up mastery in their classrooms and well as how to improve student motivations through "teacher should" statements.

Based on the information provided by Guskey, it is essential for teachers to use "preassessment results to help students identify and then review the prerequisite concepts and skills they did not possess" and then teach students the learning skills before mastery begins (Guskey 2010, p. 54). The article provided guidance on how to build my treatment by advising that teachers in mastery learning utilize frequent common formative assessments to gain results and find students who are struggling. Many mastery learning models also advise the use of Response to Interventions (RtI's) for students who are struggling so that they may begin to see advancements in their success. These RtI's could be anything from small-group direct instruction, additional practice problems, small group activities, videos to labs. Guskey also stresses the points of corrective instruction for a student struggling within the mastery framework, and that this “is not the same as "reteaching," which often consists simply of restating the original explanations louder and more slowly. Instead, mastery learning teachers use corrective instruction approaches that accommodate differences in students' learning styles, learning modalities, or types of intelligence (Sternberg, 1994)” (as cited in Guskey, 2010, pp. 55-56). Guskey’s insight provides a framework of how to deal with all types of learners. This article-helped me to determine the treatment of my students and how to provide corrective instruction, assessments and re-assessment, as well as high-quality grouping.

“Formative assessment is increasingly being used to refer only to assessment which provides feedback to students (and teachers) about the learning which is occurring during the teaching and learning, and not after” (Bell 1998, p. 539). As part of data collection and analysis, it was important to use formative assessments and summative assessments to measure the impact of mastery learning on student performance.

Some studies provided pre-tests to their students within the mastery learning framework. The researchers found that while the pre-test mastery levels were the same for the treatment and control groups, the final assessments for each were different. There was moderate correlation to mastery learning and the successes of the students in the treatment groups. They found that students who took multiple formative assessments throughout the mastery learning process had higher final test results than students who were in a conventional classroom format (Kazu, I. Y., Kazu, H., and Ozdemir, p. 241).

Another study created a student motivation questionnaire with which they surveyed students about their general feelings and attitudes about science before mastery was implemented. They created their survey “based on Keller’s ARCS motivation theory. The acronym ARCS stands for the four conditions that must exist in a motivated learner. These are attention, relevance, confidence and satisfaction” (Changeyiwo, Wambugu, and Wachanga 2009, p. 1334).

“Teachers in gap-closing schools more frequently use data to understand the skill gaps of low achieving students” (Symonds 2004, p. 15). Using common formative assessments is a big part of understanding growth when using the Mastery Framework. “Teachers need to understand the value in creating and using assessments over pre-made assessments from publishing companies” (Alzina 2016, p. 9). This guides educators towards using summative exams, short quizzes and mastery quizzes to understand student achievement as teachers venture into mastery learning. As shown in Guskey’s article, using common formative assessments is indispensable to teachers. We must use these assessments to analyze student achievement as well as when to respond to intervention for struggling students. As well as implementing common formative assessments for multiple treatment groups, it is also imperative that “teachers and administrators understanding the difference between formative assessments and summative assessments” (Alzina 2016, p. 4). The formative assessments were given along the way to help student see “what they know” versus “what they need to know” and provided a clearer path for their learning.

In Wambugu and Changeiywo’s 2008 study, researchers used the mastery learning approach to find secondary students’ motivation and achievement in physics. They used 161 students in four groups, two of which were experimental groups. They found significant differences in Physics Achievement Test scores between the experimental groups and control groups. “Experimental groups 1 and 3 which were taught using Mastery Learning Approach teaching method were higher than the means of the control groups 2 and 4, which were taught using Regular Teaching Method" (Wambugu and Changeiywo, 2008, p. 298). This provides evidence from another study that mastery learning is effective with high school physics students. Wambugu and Changeiywo also discovered that:

> …students who were taught through the MLA [mastery learning approach] teaching method achieved statistically significantly higher scores in the PAT [physics achievement test] compared to those were taught through the RTM [regular teaching method]. This implies that MLA teaching method is more effective in enhancing students' achievement (2008, p. 299).

Wambugu and Changeiywo have provided evidence to encourage utilizing mastery learning in the classroom. Through their research, it is evident that student gains are possible and by measuring preassessment and postassessment scores on the Physics Achievement Test, proven to be happening. The authors also cite that:

> …Kulik et al (1990) found out that the effects of MLA were not uniform on all students in a class low aptitude students were found to have higher gains than high aptitude students. They found out that MLA produces more gains in achievements than other teaching methods. The results of the current study agree with this because they show that students in coeducational district schools who are normally selected after national and provincial have done their selection, did better when they were taught using MLA (Wambugu and Changeiywo, 2008, p. 299).

This is an interesting finding, because although overall mastery shows gains, the effects were not spread across all students equally. Mastery is shown to elicit gains from students, both high achieving students and low achieving students.

## METHODOLOGY

### Treatment

To fully comprehend the efficacy of mastery learning in the high school physics classroom, the focus needed to stay on how implementing mastery framework affected student performance in on-level physics classes. To measure this, one also needed to consider how mastery impacted student performance on common formative assessments, how it impacted student perceptions of physics/science, as well as how mastery encouraged student motivation. Finally, it was also important to see how implementing mastery impacted me, as an educator.

This can be accomplished in several different ways, but the physics team decided that students would be given plenty of practice and flipped videos for each topic within the unit. When students started a new unit, they were handed a packet with note guides, labs, worksheets, activities, simulations, etc. Then, when students felt confident, they would take their "mastery check"—a five question quiz over that one topic. Most students tried to manage their time to stay on the suggested schedule, so usually once they had done a few class periods of practice they would try the mastery checks. Some students chose to complete all the work for a unit (between six to nine class periods) before taking any mastery checks. These mastery checks were quizzes that were closely aligned with tested content. The team worked very hard to make sure that the rigor of the questions on mastery checks was similar to the rigor of questions on the test.

Each unit was broken down into four or five topics, each with a mastery check. If students earned a score indicating "mastery," they could move on to other topics within the unit. Students had to earn at least an 80% on the mastery check before they could move on to the next topic. If they did not earn a "mastery" score, they would complete additional learning activities and try again. Students repeated this cycle for each topic within a unit, culminating in a summative exam at the end of the unit.

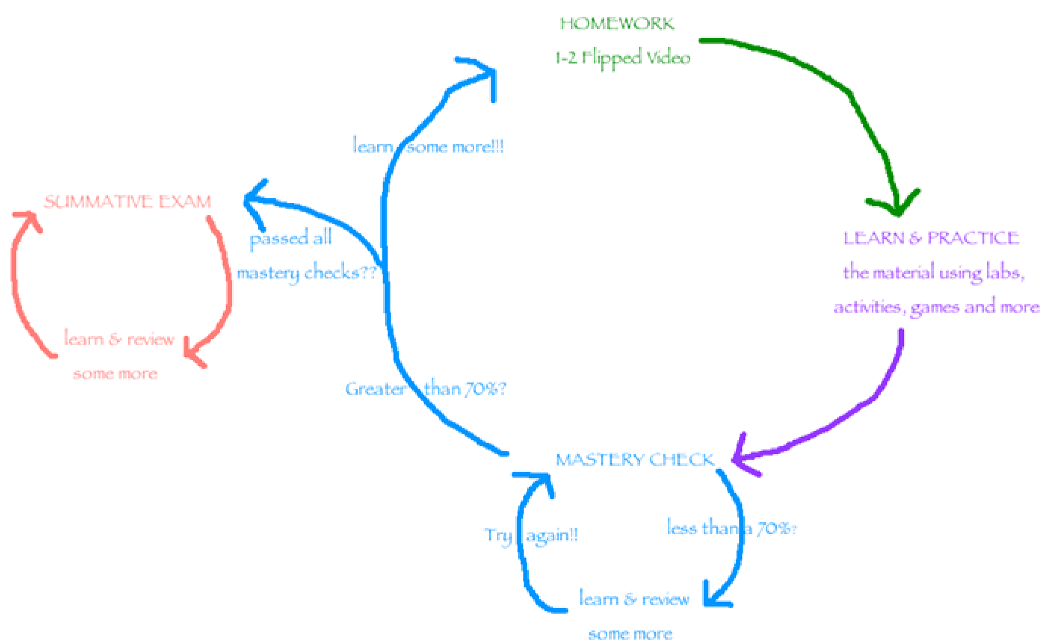


*Figure 1*. Mastery Learning Cycle (Johnson, 2017).

The idea was that as students mastered each topic within a set unit, they would perform better on the summative assessments for each unit. Treatment for the summative assessments came from a study by Robert Slavin:

> At the end of each unit of instruction a "formative test" is given, covering the unit's content. A mastery criterion, usually in the range of 80-90% correct, is established for this test. Any students who do not achieve the mastery criterion on the formative test receive corrective instruction, which may take the form of tutoring by the teacher or by students who did achieve at the criterion level, small group sessions in which teachers go over skills or concepts students missed, alternative activities or materials for students to complete independently, and so on (p. 176).

Upon completion of all required mastery checks, students could sit for the summative assessment for that unit. Students could prove mastery of a topic throughout the unit in other ways besides the mastery checks, but students had to show mastery before taking the unit exam. If students did not like their level of achievement on the summative assessment, they were given the opportunity to retake the test after completing additional reviews or studying. Students were provided one additional attempt for each summative exam, which differs from the unlimited attempts they had to show mastery on the checks throughout the unit.

Overall, mastery learning was implemented in the classroom through a series of checklists. Students who failed the mastery check, would go back to complete additional activities until they could prove mastery. Students could retake the mastery checks three times before they were required sit down with a teacher and do a “reteach” session in a small group setting. Upon completion of the tutoring, students would try the mastery check one last time. If the student still could not master the topic, additional resources were allocated towards the students’ comprehension of that topic. This continued until students were mastering each topic within a unit. There were some students who never “mastered” each topic within a unit, but if mastery of the unit could be proven with a summative unit assessment, students moved on to continue their curriculum.

Not every student ended up proving mastery within the semester. Some students moved on from their summative assessments and continued on with the curriculum. Students had to return to the content at the end of the semester for their final semester exam. While students were given the opportunity to retake any assessment, formative or summative, for full credit, few students took advantage of the opportunity. Students who did not master the topic were allowed to move on after their summative exam, though opportunities were provided in class to relearn the material and repeat the summative assessment.

The study went through several units. It started at the beginning of our year with Unit 1: Fundamental Skills, then progressed to Unit 2: Vectors and Forces (Dynamics). Then we started Unit 3: Kinematics, Unit 4: Projectiles and Frames of Reference, and finished the semester and the study with Unit 5: Circular Motion and Gravitation. Data collection only occurred during units three, four and five. Surveys were available to all students for a sample of convenience, but were usually open for a few days. Interviews with volunteer students were conducted over a two-day period during conference periods and free time for the students.

## Instrumentation

The data collection period was from October 25th to December 9th. Students could participate at any time, and provided both written feedback as well as survey results from Likert-type questions. Most students were asked to complete the surveys in class as the links were QR-codes on the board as well as announcements in our online learning management system. Students could easily access the survey, which made a big difference in participation. However, this study used a sample of convenience and therefore results can't be extended to the study population.

Table 1
*Instruments Timeline*

| Instrument | Dates Open |
|---|---|
| Science Motivation Survey | October 25th, 2016 - October 28th, 2016 |
| Flipped Classroom Survey | October 30th, 2016 - November 7th, 2016 |
| Physics Mastery Questionnaire | November 9th, 2016 - November 18th, 2016 |
| Course Evaluation | December 1st, 2016 - December 8th, 2016 |
| Interviews | December 7th, 2016 - December 8th, 2016 |

As for interviews, students were welcome to sign up for interview time slots. Since students volunteered to be interviewed, results may be a bit skewed, but overall there was a variety of students, grade averages and demographics. Interviews were conducted in small groups of two to three students after school. Students came to the classroom after class and we went through a pre-determined set of questions. As the conversation continued, occasionally other questions came up that seemed relevant to the situation. All interviews were recorded using an application on my smart phone and then transcribed.

Based on the questions and techniques, the following table shows how each research question was answered and data collection techniques used for each. It should also be known that the research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained. See Appendix A for IRB exemption.

Table 2
*Data Collection Matrix*

| Question | Assessment Data | Interviews | Surveys | Likert Scales | Journals | Field Observation |
|---|---|---|---|---|---|---|
| What is the impact of mastery on student performance on common formative assessments? | X | | | | | X |
| How will mastery impact student perceptions of Physics/science? | | X | X | X | X | X |
| In what ways will mastery encourage student ownership of learning? | | X | X | X | | |
| How does implementing mastery framework affect student performance in on-level Physics classes? | X | X | X | X | X | X |

Instrumentation for this action research project came from a variety of sources. The assessment data were common formative assessments approved by the school district that covers each curriculum standard and were administered to all on-level (non-Honors) physics students. The assessment data were combined with information about mastery checks. Student interviews were started with guiding questions to keep the discussion on track, but were interspersed with other questions to prompt student responses for clarity.

Surveys were conducted with the students with Likert scales included. The surveys and Likert scales came from previous mastery learning research that were previously studied for validity and reliability. Journal entries were completed at the end of each day by the teacher. Usually the journal entries followed the prompts but some days were just jotted down on spare paper depending on time. Some comments were also written down during class time as quotes were provided from students or when certain teaching practices improved student learning. Field observations came from watching students interact with the mastery learning model and interpreting their actions. These were also written down and compiled for general observation outcomes.

Overall, instrumentation for this project was compiled from previous research projects regarding mastery learning framework, or were guiding questions or prompts made to evaluate the efficacy of mastery learning in the general physics classroom. Each instrument aimed to answer one or more of the guiding research questions and were used in conjunction with probing questions after certain Likert scale questions to try to find the root of students' answers.

# DATA AND ANALYSIS

An imperative part of any action research project is to collect data. This can be done in many ways but for this study students were provided with a link through the online learning management system to best disperse the survey. The link led students to a Google form in which the survey questions had been added. All students were given the opportunity to participate but not all did. This provided a very diverse sample, ranging from “A” students to “F” students. These students also ranged from Special Education to gifted, as well as native speakers to English Language Learners. Students in each sample were involved in a variety of extracurricular activities including but not limited to: band, athletic training, Advanced Placement, International Baccalaureate, football, soccer, basketball, and cheerleading. Some students were involved in multiple activities; others were not involved in any. Students were given the opportunity in class to complete the survey, but could also complete it at home since the link was available to them. The surveys also had open ended questions after certain survey questions to discuss their responses to each question.

Unit three consisted of general physics concepts of motion. This included such topics as speed, velocity and acceleration in one-direction. Students worked solely in the horizontal frame of reference or only in the vertical frame of reference. Content includes some variable relationship identification, manipulating and solving various motion equations, and some vocabulary identification. Students were also expected to describe motion from graphs and data tables.

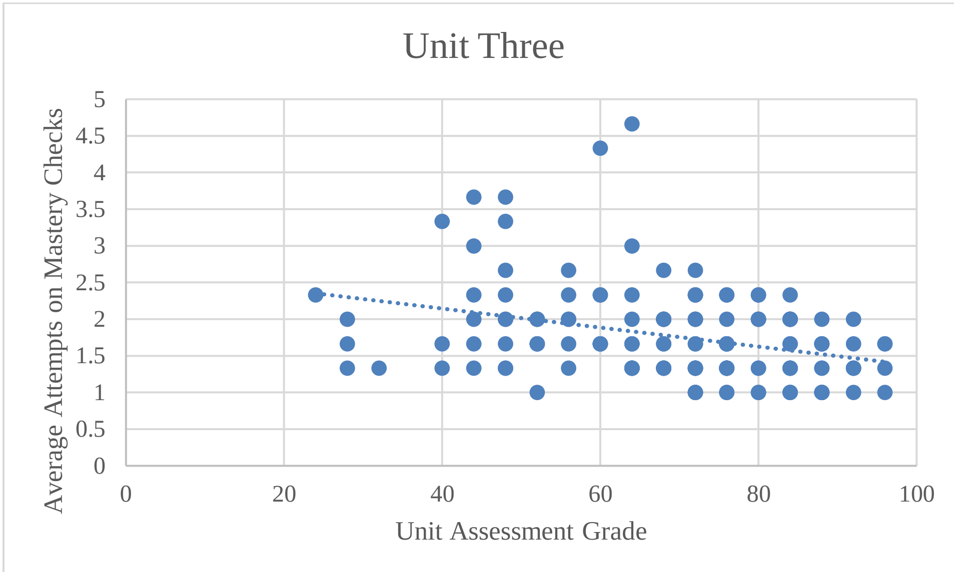


*Figure 2*. Unit Three achievement data, (*N*=143).

Student achievement must also be identified for each unit's summative assessment. This was the largest set of data, with 143 total students having taken the summative exam for unit three. Observations were made while students prepared for each unit exam using the mastery model. Some students achieved mastery on the first attempt. There were also students who achieved mastery (80%) after the first attempt, but took their second attempt to try to improve their grade. These students greatly benefitted from mastery learning model as they could improve their overall average in the class while still learning the material. Most of the students who achieved higher test scores had fewer attempts to reach mastery of the material.

It was considered that there may be a link between the number of attempts on a mastery check and the achievement of a student on their summative exam. Teachers noticed that when students needed to increase the number of attempts, the overall score for that student's summative exam was not passing. Figure 2 shows the data plot for average number of attempts on the unit three mastery checks versus the unit three assessment. While there were certainly outliers for this data set, it was determined that there was a negative correlation between the number of attempts and student achievement on the summative exam. For unit three, the correlation was found to be -0.33. As students' average number of attempts rose, the students' exam score fell. This suggests that possibly there were not enough additional curricular resources to assist students who needed more than the three attempts to earn an 80% on their mastery checks. This may have also identified a group of students who were going to keep retaking the exam without first learning the material.

One of the outliers for this test, Student A, was a student who typically retook mastery checks multiple times. His overall average number of attempts was a 4.33, but he scored just a 60 on the test. This was a student who was perpetually behind and constantly being redirected to stay on topic while he was in class. Despite many emails sent home, mandatory calendars and mandatory tutoring sessions, this student did not complete the semester. The other outlier was another student, Student B, who typically used 4.67 attempts on his mastery checks and scored just a bit better at a 64 for his test score. This student was also usually behind the recommended pacing schedule, as well as on a set tutoring schedule set up by his parents. This student, although very interested in math and science, struggled to keep pace when given the freedom to chart his own path.

The outliers aside, it was still apparent that the more mastery check attempts a student needed, the general outcome was a lower test score. This could be due to students not getting to listen to the "mini-lectures" provided at the beginning of each class if they weren't on track with the recommended schedule. Some students found it difficult to pass the quizzes even after the work. One student commented that "sometimes [you] finished all [your] work and still failed the quiz" and he said that sometimes the notes and practice weren't enough. If students were moving at the same pace, it may have been easier to track their attempts on a formative assessment and provide intervention.

Unit four consisted of general physics concepts of motion. This included such topics as speed, velocity and acceleration in two-directions. Students had to identify variables and place them in the correct frame of reference (horizontal or vertical). Equations had to be selected based on the horizontal and vertical variables they were provided, as well as recalling information about variables which remain constant throughout two-dimensional motion. Content includes some variable relationship identification, manipulating and solving various motion equations, and some vocabulary identification. Students were also expected to describe motion from graphs and data tables.

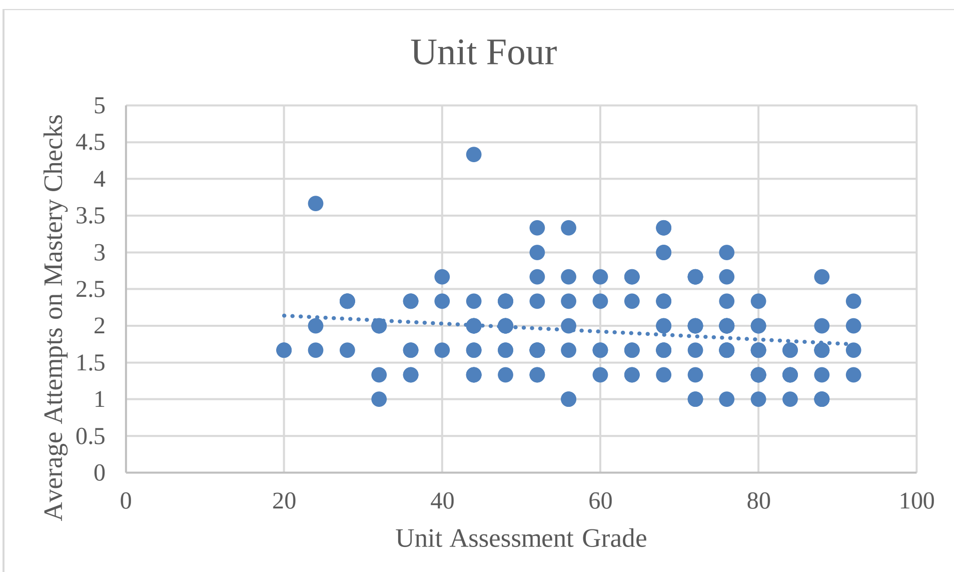


*Figure 3*. Unit Four achievement data, (*N*=138).

This was the second largest set of data, with 138 total students having taken the summative exam for unit four. Some students never completed unit four, and therefore did not meet curricular standards. Figure 3 shows the data plot for average number of attempts on the unit four mastery checks versus the unit four assessment grade. While there were certainly outliers for this data set, it was calculated that there was a negative correlation between the number of attempts and student achievement on the summative exam. For unit four, the correlation was found to be -0.08. This correlation was less than the unit three correlation, however when comparisons were made for content, historically students struggled much more with unit four content than with unit three.

Interestingly, one of the outliers for the unit four test was the same student outlier from unit three (Student A). His score on this test was a 24 and for this unit he took an average of 3.67 attempts to pass his mastery checks. The other student in unit four, Student C, was a student who had struggled all year. He came from a local private school, but had been struggling to accept tutoring as a recommended course of action. He always told me that he "never used to need tutoring" in science and "always did well." He did not take advantage of his reviews, nor did he review failing mastery checks to learn what topics he struggled with. He was an average student, usually hovering between a 60% and a 70% overall in my class.

It should be known that while not all the data agreed with the correlation, student motivation must also be considered. Many students would just click through attempts in a minute or two and then hoped that they have passed, rather than utilizing the quiz as an opportunity to learn the material. It cannot be ignored that the possibility exists that students just "didn't care" about the outcome of their mastery checks or their tests. Many students announced early on in class that they just "didn't do well" in science class and no matter what, they would not find success. These students tended to be my students who had failing grades or did not complete all the work in the semester.

Table 3

*Comparison of Test Statistics, Unit Three Test N=143, Unit Four Test N=138*

| | Unit Three Test | Unit Four Test |
|---|---|---|
| Range | 76 | 72 |
| Mean | 68 | 62 |
| Median | 50 | 56 |
| Mode | 72 | 68 |
| Standard Deviation | 17.79 | 18.11 |

Table 3 shows the individual test statistics for unit three and four. This was to help provide a knowledge base of what the test statistics look like for students. You'll notice that the average score (mean) dropped as well as the most common score (mode) from unit three to unit four. This could be related to the difficulty of the content. While unit three and four both discuss motion of objects on Earth, the advanced rigor comes from the additional dimension students must deal with when they move into unit four. Both units use the same equations and variables, however in unit four, students must also separate variables into "horizontal" and "vertical" components and dimension. The addition of this extra step made this a very abstract and difficult concept for students. Many students would place "vertical" variables in the same equation as "horizontal" variables or constants, which you cannot do and get the proper answer.

Calculating the standard deviation for each test can also provide additional statistics for the units. The standard deviation of a set of data shows how spread out the data are from one another. The standard deviation being larger for unit four shows that the data are more spread out, and therefore students' scores ranged much more significantly. Students were not finding greater success in these units under the mastery learning framework, so it is difficult to say that achievement is occurring when test statistics indicate low achievement. While comparing this year's test statistics to the same test given last year--which was taught using traditional flipped method--overall test scores dropped by almost 6% for units 3 and 4. I believe this shows that the mastery learning framework did not necessarily help students succeed. There was a trend that high aptitude students found success using mastery, while lower aptitude students struggled much more. Students who would earn As, Bs or Cs tended to enjoy the mastery framework and performed better on the summative exams. As discussed above, with students not moving at the same pace, students who were not keeping up with the recommended schedule were missing out on the valuable warm ups completed at the beginning of class. These were helpful practice problems or questions over difficult topics that were continually misconceptions for students. While these groups were different demographics, for the most part student populations were similar.

The preassessments and postassessments (Appendix B) were given before students began the unit three packet of work and then when they completed the unit four summative assessment. The assessment included questions on one-dimensional motion and two-dimensional motion as the two units (units three and four) are so closely related. Motion graphs, equations and vocabulary are similar for the two units and utilizing a combined preassessment and postassessment was the best practice to gather valuable data with which to calculate normalized gains. Of the sixteen students who completed the preassessment and postassessment, one received special services (either under 504 or special education), one had medical accommodations, but none qualified as English Language Learners. There was one senior (ages 17-18) and fifteen juniors (ages 16-17) participating in this instrument.

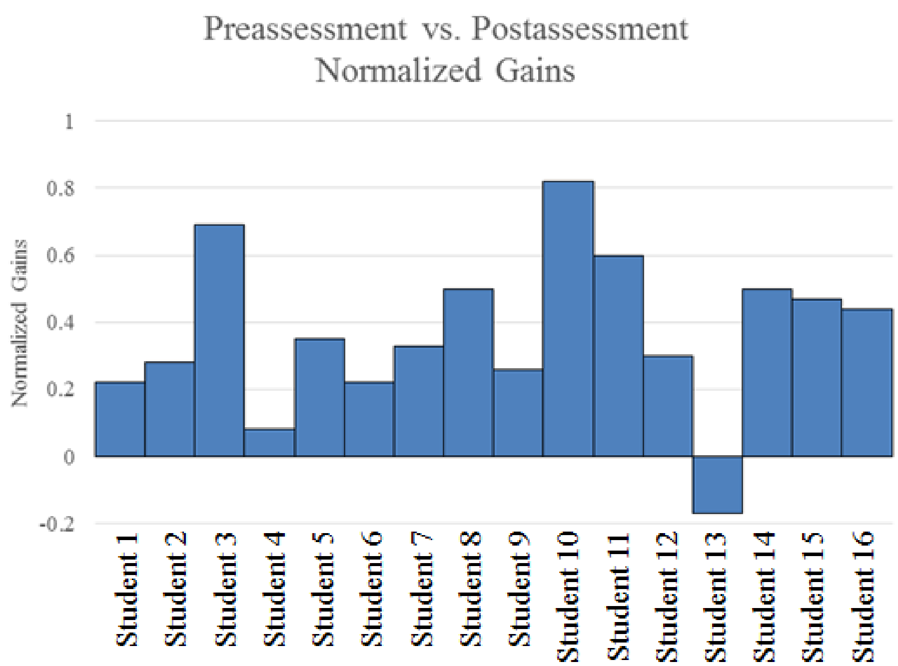


*Figure 4.* Normalized gains, (*N*=16).

Among the sixteen students who completed both preassessment and postassessment, most saw gains in their overall competency in unit three and four, both of which had the treatment applied to them. One student did not gain at all, and in fact lost points on the postassessment. Student #13 was an International Baccalaureate student who usually averages grades between 85% and 90% in physics. She was not involved in any other extracurricular activities, but did have a heavy course load. She tended to do well on her assessments, but usually needed multiple attempts on the formative assessments to reach her goal of 100% mastery. Four students saw low gains of less than 0.3. Nine students saw gains between 0.3 and 0.7, which are considered medium gains. Two students found high gains

(gains above 0.7) at 0.7 and 0.82. Student #3 was a very dedicated student. She was never behind and always had her own schedule made up for planning her units. When it came to tests, she always tested within a few days of the recommended test date. This student put forth a lot of effort when it came to her learning and was invested in her own learning. Student #10, although at first disinterested in physics, soon learned that it was “science with math in it” and grew to really enjoy the content. This helped her to become a studious student in class and caused her to go back into other units to relearn material. While the sample was small, it shows a diverse group of learners. Some have struggled with Physics, flipped learning and the mastery model. However, seeing gains in over 93% of students who participated in the preassessment/postassessment instrument, indicates that the learning models implemented in the class are assisting some students in finding success.

Unit five consisted of general physics concepts of gravitation and circular motion. This included such topics as centripetal force, centripetal acceleration and gravitational force. Students had to identify variables and place them in the correct equations. Students also had to construct ratios using the universal gravitational force equation to determine the factor of change of force. Content includes some variable relationship identification, manipulating and solving various equations, and some vocabulary identification. Students were also expected to identify force diagrams for circular motion.

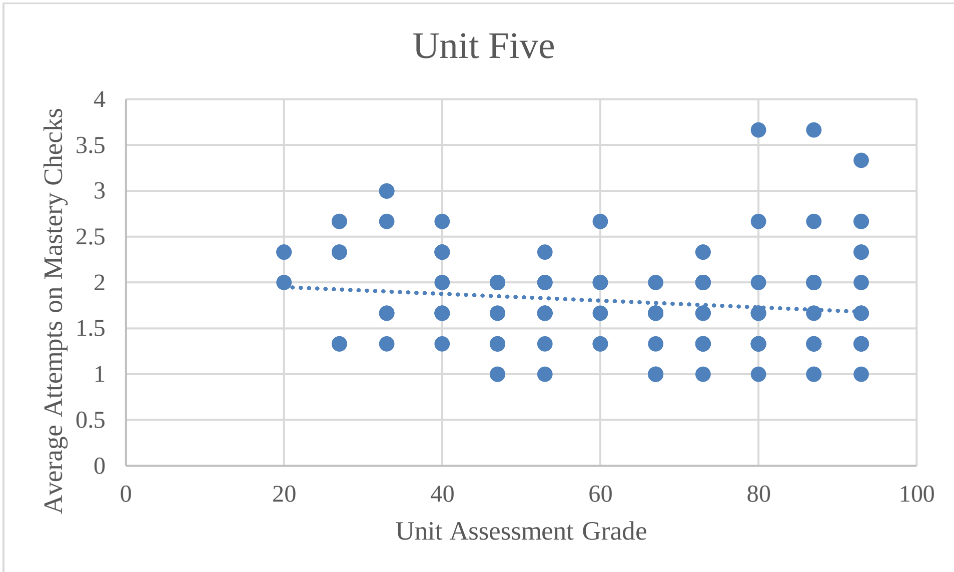


*Figure 5*. Unit Five achievement data, (*N*=120).

It should be known that using the mastery learning framework, students could take the time needed to master the subjects. This meant that not all students enrolled in the class actually completed all five units for the fall semester. In fact, 20% of enrolled students did not complete all work for unit five. As for the summative exam for unit five, 8% of students didn't take it, whether they completed all the work or not.

Unit five summative exam only included 120 students. This is because of the self-pace and the fact that a large percentage of students did not complete the unit or take the summative. Figure 5 shows the data plot for average number of attempts on the unit five mastery checks versus the unit five assessment. While there are certainly outliers for this data set, it was calculated that there was a negative correlation between the number of attempts and student achievement on the summative exam. For unit five, the correlation was found to be -0.14. Only having 80% of students complete unit five was a concern for mastery. While this was the goal of mastery, not all 80% of students who completed unit 5 reached 80%

mastery of the content. This indicates that not all students are learning to take control and ownership of their learning to follow deadlines and complete the learning objectives expected of them. They might have still passed the semester even with only completing some of the necessary curriculum units, but the state of Texas requires that all students have the opportunity to be exposed to all the units. While the students were given the packets and access to the flipped videos, most students never even looked at those end units because they were so far behind despite the constant communication and forced calendars.

Taking it one step further, it was also important to see how individual students faired in mastery learning framework. A stratified random sampling of ten students was pulled for the individual assessment of achievement, two were seniors (ages 17-18) and eight were juniors (ages 16-17). Three of the students received special services (either under 504 or special education), and five were involved in extracurricular activities through school.

Table 4
*Individual Student Achievement  N = 10*

| | Average Attempts | Unit 3 Test | Average Attempts | Unit 4 Test | Average Attempts | Unit 5 Test | Semester Exam | Semester Grade |
|---|---|---|---|---|---|---|---|---|
| Student A | 1.67 | 96 | 1.67 | 88 | 2 | 93 | 100 | 96 |
| Student B | 1.33 | 88 | 1.67 | 76 | 2 | 100 | 93 | 92 |
| Student C | 1.67 | 72 | 1.67 | 56 | 1.67 | 0 | 77 | 85 |
| Student D | 2.67 | 68 | 2 | 44 | 2.67 | 64 | 77 | 82 |
| Student E | 4.67 | 64 | 3.33 | 56 | 2 | 50 | 69 | 72 |
| Student F | 1.67 | 68 | 2 | 48 | DNF | 0 | 69 | 72 |
| Student G | 3.67 | 44 | DNF | 0 | DNF | 0 | 62 | 60 |
| Student H | 1 | 20 | 4.33 | 36 | 1.33 | 44 | 40 | 60 |
| Student I | DNF | 0 | DNF | 0 | DNF | 0 | 69 | 57 |
| Student J | 4.67 | 32 | DNF | 48 | DNF | 0 | 45 | 51 |

Table 4 shows a random pull of student data, from each of the four grade categories: A (90%-100%), B (80%-89%), C (70%-79%), D (60%-69%) and F (<60%). These students' data were compiled to show overall achievement in the mastery learning framework. While not all the achievement, or lack thereof, could be accredited to mastery, it is interesting to note that students with lower semester grades struggled to finish all unit work, and thus did not necessarily succeed in the self-paced environment. For example, Student I and Student J did not complete all their unit work. Student I did not finish all the unit three mastery checks, nor did he take his unit assessments. Student J completed unit three, but rather unsuccessfully. It is hard to say that mastery was to blame for these students' lack of progress, but it may be the self-paced environment was not conducive to their overall learning. You can see that by the more units they didn't complete, the lower their overall score, as well as the lower semester exam grade.

The data collection also included several surveys (Appendix C-E) to get opinions and attitudes towards mastery and science class. Surveys focused on achievement, confidence, perseverance and the enjoyment of class using the mastery technique.

For each question, the breakdown of each percentage was provided from Google. Google Forms took the responses of each survey participant and compiled it. Then, you could view each question and the percentages of each response. For the first survey, Science Motivation Survey (Appendix C), the sample was large at 45 students (Table 5). Of those 45 students, ten received special services (either under 504 or special education), and three were classified as English language learners. Four of the students were seniors (ages 17-18) and 41 were juniors (ages 16-17).

Table 5

*Science Motivation Survey  N = 45*

| | Student Level of Agreement | | | | |
|---|---|---|---|---|---|
| Question: | 5 – Strongly Agree | 4 -- Agree | 3 – Neutral | 2 -- Disagree | 1 – Strongly Disagree |
| Confidence | | | | | |
| 1. Whether the science content is difficult of easy, I am sure that I can understand it. | 15.6% | 44.4% | 37.8% | 0% | 2.2% |
| 2. I am not confident about understanding difficult science concepts. | 4.4% | 8.9% | 28.9% | 51.1% | 6.7% |
| 3. I am sure that I can do well on science tests. | 20% | 53.3% | 24.4% | 0% | 2.2% |
| 4. No matter how much effort I put in, I cannot learn science. | 4.4% | 2.2% | 4.4% | 51.1% | 37.8% |
| 5. When science activities are too difficult, I give up or only do the easy parts. | 4.4% | 6.7% | 22.2% | 48.9% | 17.8% |
| 6. During science activities, I prefer to ask other people for the answer rather than think for myself. | 2.2% | 0% | 35.6% | 40% | 22.2% |
| 7. When I find the science content difficult, I do not try to learn it. | 0% | 0% | 11.1% | 55.6% | 33.3% |
| Motivation | | | | | |
| 8. When learning new science concepts, I attempt to understand them. | 40% | 55.6% | 4.4% | 0% | 0% |
| 9. When learning new science concepts, I connect them to my previous experiences. | 15.6% | 33.6% | 35.6% | 13.3% | 2.2% |
| 10. When I do not understand a science concept, I find relevant resources that will help me. | 24.4% | 55.6% | 17.8% | 2.2% | 0% |
| 11. When I do not understand a science concept, I would discuss with the teacher or other students to clarify my understanding. | 33.3% | 53.3% | 8.9% | 4.4% | 0% |
| 12. When I meet science concepts that I do not understand, I still try to learn them. | 26.7% | 66.7% | 6.7% | 0% | 0% |

Table 5 Continued
*Science Motivation Survey  N = 45*

| | Student Level of Agreement | | | | |
|---|---|---|---|---|---|
| Question: | 5 – Strongly Agree | 4 -- Agree | 3 – Neutral | 2 -- Disagree | 1 – Strongly Disagree |
| Participation | | | | | |
| 13. I participate in science courses to get a good grade. | 28.9% | 51.1% | 15.6% | 4.4% | 0% |
| 14. I am willing to participate in this science course because the teacher uses a variety of teaching methods. | 13.3% | 28.9% | 35.6% | 15.6% | 6.7% |
| 15. I am willing to participate in this science course because the teacher does not put a lot of pressure on me. | 15.6% | 46.7% | 28.9% | 8.9% | 0% |

Based on the information gathered from the survey, trends show that students were willing to put in effort into science class, even when the content was difficult. The majority of students—almost 56%—disagreed when asked if they do not try to learn science content when it is difficult. When asked if they believed they could understand science topics regardless of difficulty, 60% of students responded that they agreed or strongly agreed. To further identify this trend, almost 89% of students said they disagreed or strongly disagreed with the statement that “no matter how hard they tried, they could not learn science.” This showed that students were willing to persevere and continued working through science. Because so many students agreed that they could be successful and believed they could be successful in science no matter what, this showed that the students believed they were motivated to do well.

Students seemed to be motivated by their grades in the class, as 80% of the students said that they participate in class to earn good grades. While this was an indicator of motivation, the 62.3% of students who said they participate due to lack of pressure on them answered the question of how mastery affected student motivation, as the large number of students stated that the “no pressure” environment incited them to participate. Since this was a sample of convenience, and only students who wanted to participate were included, the views of these students may have skewed results in the positive direction.

One of the research questions asked how mastery affected their perceptions of science, and due to their responses, the patterns showed that students were more likely to put in additional effort to find success. When surveyed, 95.6% of the students said that they attempted to understand science concepts, and 80% of students reported that they tried to find relevant resources to try to understand concepts that gave them difficulties. The perseverance that students were reporting was high, with 93.4% of students saying that they still try to learn science concepts even when they were very difficult. This shows that students were willing to keep trying and had the motivation required to master topics, even when it was very difficult.

The information found in the first survey was helpful to the research study in that it showed trends indicating that students were motivated to work in the science classroom. This was helpful, because as mastery was implemented in the classroom, students needed to have self-motivation to keep on pace and complete their work in their own time. Each student had their own needs for time and it was helpful for them to keep motivation levels high.

It was also interesting that students indicated that they participated more in the science class due to the “lack of pressure” they felt. Many students indicated they “like being self-paced” and enjoyed the fact that “the teacher didn’t put pressure on anybody unless they were falling behind.” This was helpful because students were expressing the main goals of mastery: to allow students the time they needed to learn the material. Mastery allowed students to complete their work in a less stressful environment. One student said, “With the Mastery learning, I can go at my own pace, so I didn't necessarily feel pressure to get things done unless a test was coming up.”

Other students said that their desire to pursue higher education was what motivated them to do well in class. One student suggested that the motivation to participate and do well in this class was an “investment in [his] future.” Many other students followed a similar trend by saying that mastery learning in this class helped them to prioritize classes and assignments so they could spend additional time on their advanced academics courses and their other activities they felt are necessary for success in college. Throughout the first instrument, a new trend had come about that these students were persevering through the work even when it was difficult. It would be interesting to see if this trend continued through other instruments and surveys.

Overall, most students agreed that mastery/self-paced learning allowed them the time they needed to complete the work successfully, while still learning skills like time management. Students also suggested that their motivation levels were high for the class because the teacher and other students had time to help with difficult topics due to the flipped classroom and mastery framework.

The following survey was conducted in class using a sample of convenience. For this survey (Appendix D), there were 42 total respondents, one senior (age 17-18) and 41 juniors (ages 16-17). Of these 42 students, one was identified as an English Language Learner and seven received special services (either under 504 or special education). The 42 total respondents included students of all grade averages, with 12 of the 42 (28.5%) students averaging overall grades 79% or lower.

Table 6

*Flipped Classroom Survey  N = 42*

| | Student Level of Agreement | | | | |
|---|---|---|---|---|---|
| Question: | 5 – Strongly Agree | 4 - Agree | 3 – Neutral | 2 - Disagree | 1 – Strongly Disagree |
| Flipped Instruction | | | | | |
| 1. The flipped classroom gives me less class time to practice science. | 7.1% | 4.8% | 26.2% | 52.4% | 9.5% |
| 2. The Flipped Classroom is more engaging than traditional classroom instruction. | 4.8% | 19% | 21.4% | 31% | 23.8% |
| 3. I would not recommend the Flipped Classroom to a friend. | 16.7% | 23.8% | 35.7% | 16.7% | 7.1% |
| 4. The Flipped Classroom gives me greater opportunities to communicate with other students. | 2.4% | 33.3% | 26.2% | 26.2% | 11.9% |
| 5. I would rather watch a traditional teacher led lesson than a lesson video. | 16.7% | 33.3% | 31% | 16.7% | 2.4% |
| Technology in Flipped Classroom | | | | | |
| 6. I like watching the lessons on video. | 7.1% | 19% | 26.2% | 28.6% | 19% |
| 7. Social media (YouTube, Twitter, Facebook) is not an important part of my learning. | 7.1% | 33.3% | 35.7% | 19% | 4.8% |
| 8. I regularly watch the video assignments. | 19% | 54.8% | 14.3% | 11.9% | 0% |
| 9. I like taking my tests and quizzes online using Canvas. | 14.3% | 35.7% | 16.7% | 21.4% | 11.9% |
| Self-Paced Instruction | | | | | |
| 10. I would rather have the entire class moving at the same pace in the course. | 19% | 26.2% | 23.8% | 26.2% | 4.8% |
| 11. I dislike that I can take quizzes at my own pace. | 7.1% | 7.1% | 26.2% | 42.9% | 16.7% |
| 12. I dislike self-pacing myself through the course. | 4.8% | 19% | 40.5% | 26.2% | 9.5% |
| 13. I find it easy to pace myself successfully through the course. | 7.1% | 28.6% | 35.7% | 16.7% | 11.9% |
| Motivation in Flipped Classroom | | | | | |
| 14. I am more motivated to learn science in the flipped classroom. | 4.8% | 14.3% | 31% | 35.7% | 14.3% |
| 15. I feel that mastery learning has improved my science understanding. | 7.1% | 28.6% | 38.1% | 14.3% | 11.9% |
| 16. The flipped classroom has not improved my learning of science. | 9.5% | 23.8% | 33.3% | 23.8% | 9.5% |

The data above could be summarized into bell-shaped curves; meaning that the data fell into a normal distribution. Survey responses aligned strongly to ‘neutral’ or ‘agree’ and ‘disagree’. Most survey responses had few ‘strong’ feelings, which led the survey responses to being fairly bell-shaped. Of the 16 questions, 3 were skewed strongly negatively, with 2 of the 3 questions acting as “pro-flipped” indicators. The indicators showed that almost 55% of students enjoyed self-pace in the course, and almost 60% enjoyed taking quizzes and tests at their own pace when they feel most prepared. While 52.4% of students said flipped classroom give them more class time to practice science, 54.8% of students also said that flipped classroom was less engaging than a traditional class, despite the extra time to practice science. In other opposing views, 45.2% of students wished the class went at the same pace, with the entire class moving together through units, but 59.6% of students enjoyed being able to take their quizzes and tests when they felt prepared.

The conflicting views continued throughout the survey, where students enjoyed the freedom of self-paced quizzes, but wished they had the whole class moving together. The student responses showed that 50% of students did not feel motivated by flipped classroom to learn science. Results were inconclusive when asked if mastery learning or flipped classroom improved science understanding or learning of science. While this data showed that 50% of students’ motivation in science class improved through flipped classroom, almost 40% of students responded that mastery did not have an impact on their science understanding, as they reported ‘neutral’ feelings towards mastery framework. The flipped classroom in its relation to the mastery framework set up in class was seen as a burden for some students. Almost half the students surveyed (47.6%) state that they did not like watching the lectures on video. The flipped classroom and mastery framework did not show a positive correlation for student motivation and confidence. It was indicative that only half the students (+/- 5%) felt confident and enjoyed the flipped mastery framework.

The following survey was conducted in class using a sample of convenience. For this survey (Appendix E), there were 39 total respondents, all of whom were juniors (ages 16-17). Of these 39 students, seven received special services (either under 504 or special education). The 39 total respondents included students of all grade averages, with 17 of the 39 (43.5%) students averaging overall grades 79% or lower.

Table 7
*Physics Mastery Questionnaire  N = 39*

| | Student Level of Agreement | | | | |
|---|---|---|---|---|---|
| Question: | 5 – Strongly Agree | 4 - Agree | 3 – Neutral | 2 - Disagree | 1 – Strongly Disagree |
| Confidence | | | | | |
| 1. Learning physics using mastery learning approach has: made me love physics | 0% | 10.3% | 43.6% | 15.4% | 30.8% |
| 2. Learning physics using mastery learning approach has: been dull and boring. | 12.8% | 28.2% | 30.8% | 28.2% | 0% |
| 3. Learning physics using mastery learning approach has: made physics enjoyable. | 2.6% | 25.6% | 25.6% | 28.2% | 17.9% |
| 4. After learning Physics using mastery learning approach: I expect to score highly in physics tests. | 5.1% | 33.3% | 30.8% | 10.3% | 20.5% |
| 5. After learning Physics using mastery learning approach: I find learning physics is in itself rewarding. | 2.6% | 15.4% | 48.7% | 15.4% | 17.9% |
| 6. After learning Physics using mastery learning approach: I no longer feel uneasy during physics lessons. | 2.6% | 25.6% | 35.9% | 23.1% | 12.8% |
| 7. After learning Physics using mastery learning approach: I can now study and solve problems in physics on my own. | 5.1% | 38.5% | 25.6% | 15.4% | 15.4% |
| 8. After learning Physics using mastery learning approach: I expect to perform well in other science subjects. | 2.6% | 28.2% | 46.2% | 12.8% | 10.3% |
| 9. After learning Physics using mastery learning approach: I am able to work independently in physics exercises in and outside physics classrooms. | 7.7% | 30.8% | 30.8% | 17.9% | 12.8% |
| 10. After learning Physics using mastery learning approach: I am dissatisfied with my participation in classroom physics activities. | 5.1% | 15.4% | 41% | 35.9% | 2.6% |
| 11. After learning Physics using mastery learning approach: I do not expect to be successful in physics tasks given by physics teachers in the classroom. | 12.8% | 7.7% | 23.1% | 48.7% | 7.7% |

Table 7 Continued

*Physics Mastery Questionnaire  N = 39*

| | Student Level of Agreement | | | | |
|---|---|---|---|---|---|
| Question: | 5 – Strongly Agree | 4 - Agree | 3 – Neutral | 2 - Disagree | 1 – Strongly Disagree |
| Motivation | | | | | |
| 12. Learning physics using mastery learning approach has: made learning physics frustrating | 28.2% | 25.6% | 23.1% | 20.5% | 2.6% |
| 13. Learning physics using mastery learning approach has: highly motivated me to work hard in physics. | 0% | 33.3% | 33.3% | 12.8% | 20.5% |
| 14. Learning physics using mastery learning approach has: helped me to discover skills in physics. | 7.7% | 30.8% | 25.6% | 20.5% | 15.4% |
| 15. After learning physics using mastery learning approach: I find it hard to work independently. | 12.8% | 23.1% | 25.6% | 28.2% | 10.3% |
| 16. After learning Physics using mastery learning approach: I am now satisfied with the way I learn physics. | 9.5% | 23.8% | 33.3% | 23.8% | 9.5% |
| 17. After learning Physics using mastery learning approach: I was satisfied with the way physics was taught in the classroom. | 10.3% | 28.2% | 23.1% | 25.6% | 12.8% |

In identifying student motivation and confidence, 56.4% of students reported ‘disagree’ or ‘strongly disagree’ to the statement that they “do not expect to be successful in physics tasks given by physics teachers in the classroom.” When asked if after learning physics using mastery learning approach they could now study and solve problems in physics on their own, 43.6% of students said they ‘agreed’ or ‘strongly agreed’ to those statements.

However, in measuring student motivation, 53.8% of students ‘agreed’ or ‘strongly agreed’ that learning physics using mastery learning approach made learning physics frustrating. One student stated that “[he] feel behind all the time because with no due dates, [he] end up prioritizing other classes with due dates over physics” and that mastery just “motivates [him] to procrastinate more.” The survey provided little correlation between mastery learning framework and student motivation. Even with student confidence, very few students reported feeling more confident or successful with tests.

## INTERPRETATION AND CONCLUSION

A fellow colleague who was implementing mastery framework said about student achievement with mastery, “The rich get richer and the poor get poorer.” By this he meant that kids with “good” grades ended up doing better than normal, but kids with borderline grades ended up doing worse-- much worse. Students, who seemed to be capable of the work, were unable to monitor their time or prioritize their self-paced physics curriculum and failed to finish the semester in time. Our current school system is not set up to allow students to complete work after the semester ends, nor is it set up for students to apply mastery strategies from early years.

Implementing mastery framework affected student performance in several ways. Although mastery was not overall effective in improving student performance, we did see some gains from high achieving students. High aptitude students seemed to flourish with the ability to self-pace and retake mastery checks for higher grades and increased learning. These students found that if they repeated mastery checks, they saw more of the content and were more prepared for the tests. Alternately, more average students tended to put off work until the last minute and struggled to keep up with the work load and the self-paced class. Low-achieving students really struggled with the autonomy within the mastery learning approach. While this could be attributed to general apathy and disinterest, mastery may not have been helping to combat this. For example, as you look through students who scored an “A”, a “B”, a “C”, “D” or “F” you can see that students were less likely to finish units with mastery (See Table 4.)

A guiding question for this study is how mastery framework would impact student achievement on formative assessments. At the beginning of the study, it was hoped that the mastery checks would prove content knowledge for various units, and then would increase student achievement on formative assessments. As you look through the units that were used in the study, you can see a negative correlation between the number of attempts needed to master a topic and the summative assessments. In unit 3 (see Figure 2), unit 4 (see Figure 3) and unit 5 (see Figure 5) there were negative correlations in each unit. This is evidence that mastery did not necessarily help students on summative assessments. Regarding common formative assessments, my students typically required multiple attempts to earn the passing grade for mastery (80%). It's difficult to say how many of these attempts were just to earn a better grade, or if it was multiple attempts to just reach the required grade to move along. I do not believe that mastery aided students in performing better on common formative assessments or on summative assessments.

Mastery was to be the learning framework that would encourage positive student interactions with science. Most students remained fairly neutral on their opinions of physics (Table 7). Students didn't necessarily enjoy physics more or less because of mastery learning approach. Mastery learning didn't improve student confidence by a large margin, nor did it make students want to pursue physics in further studies.

However, in one area of the research questions, mastery did help a specific group of students. Motivation was key in our higher achieving students. For example, students reported that they tried to understand concepts before just abandoning the topic (Table 5 & 7). They also said that mastery helped them want to work on physics because they knew they had the time they required and didn't feel much pressure from the teacher [me] to get work done. Many students appreciated the self-paced framework, but many students also reported feeling anxiety over the fact they had no structure, and were not used to the freedom that came with the mastery learning approach. Overall, I think students' motivation levels increased because of the lack of pressure or deadlines.

Finally, the impact on me as an educator was the last guiding question for this action research project. Overall, this project has opened my eyes to better ways to question my teaching practices. I think doing mastery as my research project did not necessarily aid my students in their success, but it did make me question my teaching practices and wonder on a larger scale the effects of my teaching. This has helped me determine if there are further questions and research topics I can study on a smaller scale. I'd like to know if flipped learning is really the most effective strategy for the secondary physics classroom.

Some limiting factors in this study were the students' first exposure to mastery learning, which could indicate that students do not understand the responsibility level on them to take ownership of their learning to monitor their own progress. Another limiting factor is the ability level of the student demographic. While there are very advanced students in the general physics classes, there are also a majority of students who struggle in math and science. Many students also struggle to apply themselves, and indicated several times in interviews and surveys that "to show us videos we don't even hardly watch, we just skip through to fill [in] the notes" is indicative of teachers "being lazy," rather than embracing the videos as a learning opportunity. Students in the district are forced to take physics in order to graduate. Since physics is a required class, there are no pre-requisite classes or skill levels—such as math level completed to find success. It's also difficult to encourage students to do additional work to find success when they didn't want to enroll in the class to begin with. In other courses with our same students, teachers are finding success with mastery because the students are choosing to be in the course and find the curriculum meaningful to their own personal interests.

Additionally, students reported several times that not having a “guideline or schedule to follow made it very hard to know what [they] should work on each day.” Another student stated that “it would be helpful to keep more to a strict schedule so you finish everything and get it done” with plenty of time to finish the semester. Many students reported that mastery learning “stressed them out” because they didn’t always know how much work they should have done and it kept them “procrastinating a lot” because they knew they could have extra days to turn in physics work. Students tended to prioritize other classes with strict deadlines, which occasionally meant that students would work on history or English instead of physics. A large majority of our work can be done from home or in tutoring because of the nature of students being able to work on whatever they wish, or in whatever order.

Overall, I do not believe mastery learning is a successful strategy for general education physics students when it is a required course for high school students. As students required more mastery check attempts, it was detrimental to their overall test average. Students struggled to stay on schedule, and thus, missed valuable “mini-lectures” during the bell work warm ups each class. If students had been exposed to mastery learning from fifth or sixth grade through eleventh grade, it may be a different story. However, because of the nature of the public school system in Texas, we do not have the luxury of extending semesters to truly allow students to master the subject matter. Students may be more successful at a mastery learning course if they attended a school system that used mastery learning throughout secondary education. They would then develop the time management and independent learning skills to be successful for a physics mastery learning course. Furthermore, students would be more successful if they were not bound to an arbitrary calendar set by the state. I also believe that using a modified mastery learning framework may find more success in a required class. Within our own school building, teachers in elective science classes found success using mastery learning.

Changes that could be made to improve the study would be to focus the questions a little better to keep them all answering specific research questions. Many questions do not seem to provide valuable information, such as “participating in science class to get good grades.” Unfortunately, it was rare to find a student who does not value their grades over their learning, or find that they measured their success through their grades. After gathering the data, not all questions were providing valuable information, or were not answering a research question. Improving the questioning through surveys may have streamlined the results.

Another way this study could be improved moving forward is by using a more synchronous mastery structure. With many synchronous mastery learning frameworks, the remedial students get one or two chances, and then they move on regardless of their achievement level or completion level of each unit of study. Sometimes while that is happening, the students who have already proved mastery of that unit get one or two more enriched activities so everyone is all together. All students would be kept together in that approach.

It would also be beneficial to extend the study to include traditional classroom standards versus flipped versus mastery. Including all three as a comparison would be helpful so that student achievement could be compared across all three learning approaches.

Although, one student said "it's about how you study not the teaching approach" that makes the difference between success and failure.

Many of the mastery checks were not well-aligned with the tests, so students may have passed all mastery checks first try, but then struggled on the summative assessments because of the lack of alignment with standards and questioning techniques. The mastery checks also did not always have enough questions built into them. Students took the check once and saw five questions. On the second attempt, they may see three new questions and two repeated. By the third attempt, students would have seen 8 of the 10 questions available. This means students would likely pass without actually learning the material. While this is easily remedied, it is a limitation to the study that could be improved.

Finally, a strong improvement to the study would be to track a single group of students as they progressed from a traditional classroom, to flipped, to mastery rather than identifying volunteers throughout all classes. With no comparisons to other type of learning approaches, it is difficult to recognize the efficacy of mastery learning in the high school physics classroom. However, the volunteer sample size was also a challenge. Some of the results were obtained because I found a willing group of students. This meant the sample of convenience changed with each survey, and it was usually more high-achieving and on-schedule students who tended to volunteer for surveys and interviews.

Throughout the data analysis it was interesting to see the differences for students determining how they made it through difficult topics. I would be interested to see how students persevered and continued even when faced with difficulties. It may become a new research question to identify trends within student perseverance and growth. This research study has also presented an important question in my classroom: whether flipped classroom is really the best option for learning versus traditional classroom lecture. Many of my students have cited “disliking flipped classroom” and feel as though they’d prefer more “teacher-led instruction.” I’d like to do another research study about whether that is true, or to investigate the benefits of traditional versus flipped classroom.

## VALUE

Moving forward, data indicated that mastery learning was not necessarily effective in the high school physics classroom. I think there are many reasons that this is true, despite all of the literature that states otherwise. Having a wide ability of math skills made it difficult to implement mastery, as well as the lack of class choice involved in my student demographic. Mastery was very effective for student achievement when you consider students who were in the upper levels of aptitude. Unfortunately, it was not as successful for students in the lower percentile. It is possible that the use of a modified mastery framework could be more successful in a required course like mine. I’d say that more than likely, my future will continue to determine the efficacy of flipped classroom versus traditional classroom. The surveys and interviews showed that most students believe they would prefer a traditional lecture class, with homework completed outside of class. This action research process has helped me to see how to best question my students to find out what they need to feel successful and supported in the classroom. The best question I asked my students was “How can this class, or I, improve?” It gave my students the opportunity to tell me what they needed (more structure, less choice) or what I could do to help support them as they moved along. Several students were very honest with me in the surveys, but I’d also like to see more surveys at the beginning of an academic school year to know my students’ learning and study habits. Then I can more efficiently tailor their supports to their specific needs.

In physics this year, we spent the first half doing asynchronous mastery, and the second half transitioned into a more traditional flipped classroom, rather than mastery. Since the observations made throughout the fall semester and the implementation of mastery, we all agreed to switch our teaching approach to meet the needs of our students. We transitioned to a more structured approach so students are receiving the same packets as they received during mastery, but now each class period, students have a pre-determined activity they should complete and get checked off. The mastery checks are open for an available three attempts, but because of the set dates they take the mastery checks, I feel more students are needing fewer attempts. There are still students who are behind, students who don't do the assigned work, and students who need additional supports to find success.

This action research project has made me much more introspective about my teaching practices and how students perceive flipped classroom and educators, in general. Moving into the next phases of my career, I want to be sure I am teaching my students how to be independent learners and how to search for answers and education wherever they can. To learn that I am a support and a cheerleader for them, but refuse to do the work for them. I'd like to make sure that I send into the world a student who is just a little more independent and capable of owning their education and advocating for their needs. I will continue to question my students on how they can be supported and in which ways I can teach them skills necessary to find success in my class. I believe this has taken my skills as an educator just one step further and helped me to be a more successful and effective teacher, even if mastery didn't work for my classroom or my students. I'd like to continue improving and always looking for the best thing for my students. It was never about doing what's best for me, but always about improving what's happening for my students.

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# APPENDICES

# APPENDIX A

# INSTITUTIONAL REVIEW BOARD EXEMPTION

# INSTITUTIONAL REVIEW BOARD
**For the Protection of Human Subjects**
**FWA 00000165**

MONTANA STATE UNIVERSITY

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**MEMORANDUM**

**TO:** Sara Holloway and Walter Woolbaugh

**FROM:** Mark Quinn *Mark Quinn CJ*

**DATE:** September 29, 2016

**RE:** *"Impact of Mastery Learning on Physics Students" [SH092916-EX]*

The above research, described in your submission of **September 29, 2016**, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

# APPENDIX B

## PREASSESSMENT AND POSTASSESSMENT

Student ID Number: ________________________________Date: ___________________
Note: Participation in this research is voluntary. Participation or non-participation will not affect your grades or eligibility to participate in any other class activities.

A car slows down from 48 m/s to 12 m/s over 5.0 seconds. What is the acceleration of the car during this time?

A truck travels down a straight road at 0.278 m/s for 0.40 meters. How long did this trip take?

Determine the displacement of a plane that experiences a uniform acceleration of 1.83 $m/s^2$ to the north with an initial velocity of 66 m/s north in 12 seconds.

How far will a bullet travel in 0.0001s at 200 m/s?

A car starts from rest and accelerates 5.2 $m/s^2$ after a traffic light turns green. How far will it have gone if it is traveling at 50 m/s?

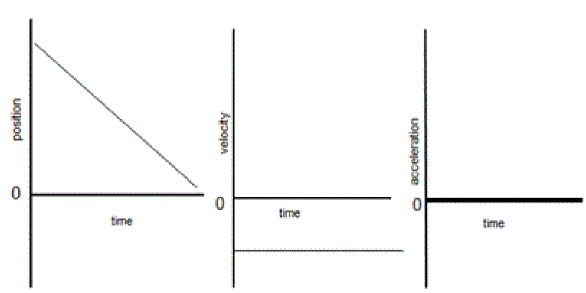
A baseball is hit at some angle. At some point in its flight, its horizontal velocity is 30 m/s and its vertical velocity is -40 m/s. What is the magnitude of the resultant velocity of the baseball?

A stone is dropped from a cliff. After it has fallen 689 m, what is the stone's velocity?

Neglecting air resistance, calculate the distance that a cannonball launched horizontally will be after 1 second if the cannonball has a barrel velocity of 100 m/s.

An object is projected horizontally at 7.0 m/s from the top of a 44 m cliff. How far from the base of the cliff will the object strike the ground?

The initial velocity of a paper airplane shot vertically is 24 m/s. How high will it go? How long does it take to reach that height?

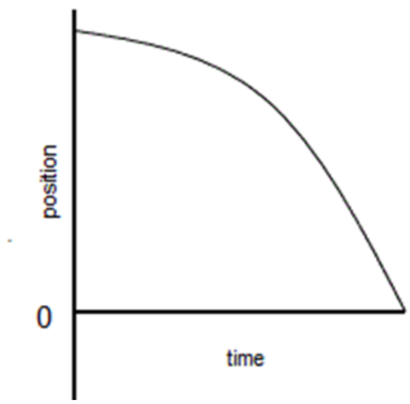



Describe the motion of a platypus using the graphs above:

Big Bird throw a worm at a velocity of 6 m/s at a height of 8 meters, while at the same time a large black bird drops a worm from the same height. Which worm hits the ground first?

You're walking forward at a velocity of 0.4 m/s on a bus traveling 3 m/s. How fast are you traveling compared to a person standing on the street watching you go by?

Describe the speed and acceleration of a peacock using the graph below:




A boat attendant walks towards the back of the boat at a velocity of 0.8 m/s. If the boat is going 50 m/s, what is the boat attendant's velocity compared to the ground?

The horizontal acceleration of a projectile is always ______________________________.

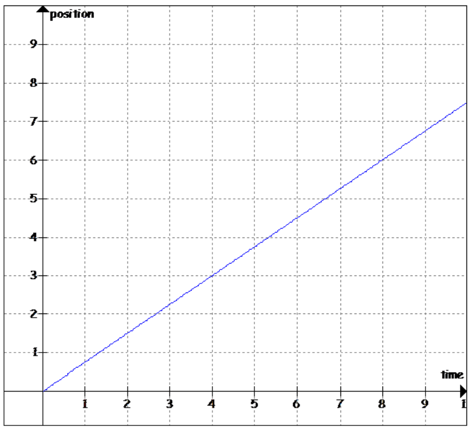
When a ball reaches the top of its path, the vertical velocity is _______________________.

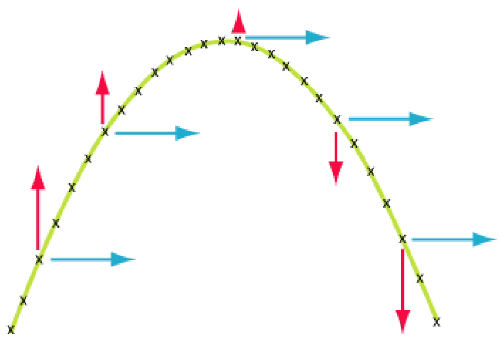
When you have a projectile flying through the air, what two variables are changing?

The vertical acceleration of a projectile is always __________________.

You are in a bus going 55 m/s. You pass a tree. In your frame of reference, how fast is the tree moving?

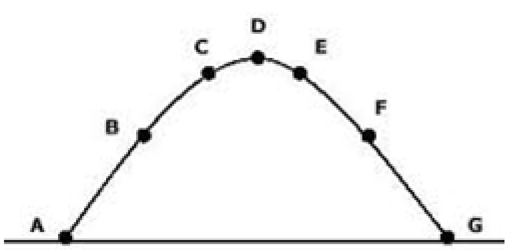
The position-time graph shows the position of a hamster. Calculate the velocity for the hamster.



According to the image to above (and real life), horizontal velocity is

________________________.




Which two points in this path have the same speed?

# APPENDIX C

## STUDENT’S MOTIVATION TOWARDS SCIENCE LEARNING QUESTIONNAIRE

SURVEY INSTRUMENT 1

Student ID Number: ________________________________Date: ___________________

Note: Participation in this research is voluntary. Participation or non-participation will not affect your grades or eligibility to participate in any other class activities.

Please indicate your responses to this survey using the following key:

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| A | B | C | D | E |

1. Whether the science content is difficult or easy, I am sure that I can understand it.
2. I am not confident about understanding difficult science concepts.
3. I am sure that I can do well on science tests.

    Why did you answer the way you did on the previous question?

4. No matter how much effort I put in, I cannot learn science.
5. When science activities are too difficult, I give up or only do the easy parts.
6. During science activities, I prefer to ask other people for the answer rather than think for myself.
7. When I find the science content difficult, I do not try to learn it.

    Why did you answer the way you did in the previous question?

8. When learning new science concepts, I attempt to understand them.
9. When learning new science concepts, I connect them to my previous experiences.
10. When I do not understand a science concept, I find relevant resources that will help me.
11. When I do not understand a science concept, I would discuss with the teacher or other students to clarify my understanding.
12. When I meet science concepts that I do not understand, I still try to learn them.
13. I participate in science courses to get a good grade.
14. I am willing to participate in this science course because the teacher uses a variety of teaching methods.
15. I am willing to participate in this science course because the teacher does not put a lot of pressure on me.

    Why did you answer the way you did in the previous question?

# APPENDIX D

# STUDENT PERCEPTIONS OF THE FLIPPED CLASSROOM

SURVEY INSTRUMENT 2

Student ID Number: ________________________________Date: ____________________
Note: Participation in this research is voluntary. Participation or non-participation will not affect your grades or eligibility to participate in any other class activities.

Please indicate your responses to this survey using the following key:

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| A | B | C | D | E |

1. The Flipped Classroom is more engaging than traditional classroom instruction.
2. I would not recommend the Flipped Classroom to a friend.
   Why did you respond the way you did in the previous question?
3. The Flipped Classroom give me greater opportunities to communicate with other students.
4. I like watching the lessons on video.
5. I would rather have the entire class moving at the same pace in the course.
   Why did you respond the way you did in the previous question?
6. I am spending less time working on traditional science homework.
   Why did you respond the way you did in the previous question?
7. Social media (YouTube, Twitter, Facebook) is not an important part in my learning.
8. I regularly watch the video assignments.
9. I dislike that I can take quizzes at my own pace.
10. I like taking my tests and quizzes online using Canvas.
11. I would rather watch a traditional teacher led lesson than a lesson video.
    Why did you respond the way you did in the previous question?
12. I feel that mastery learning has improved my science understanding.
13. I dislike self-pace myself through the course.
14. I find it easy to pace myself successfully through the course.
15. The flipped classroom gives me less class time to practice science.
    Why did you respond the way you did in the previous question?
16. I am more motivated to learn science in the flipped classroom.

17. The flipped classroom has not improved my learning of science.

What are the advantages of flipped classroom?

What are the disadvantages of flipped classroom?

Would the flipped classroom be useful for other subjects? Why or why not?

# APPENDIX E

# STUDENT'S MOTIVATION QUESTIONNAIRE

SURVEY INSTRUMENT 3

Student ID Number: ________________________________Date: ____________________
Note: Participation in this research is voluntary. Participation or non-participation will not affect your grades or eligibility to participate in any other class activities.

Please indicate your responses to this survey using the following key:

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|
| A | B | C | D | E |

Learning Physics using mastery learning approach has:

1. Made me love physics.
2. Made learning physics frustrating.
3. Been dull and boring.
4. Made physics enjoyable.

   Why did you respond the way you did in the previous question?
5. Highly motivated me to work hard in physics

   Why did you respond the way you did in the previous question?
6. Helped me to discover skills in physics

After learning Physics using mastery learning approach:

7. I find it hard to work independently
8. I expect to rarely be able to apply physics in life situations
9. I do not expect to be successful in physics tasks given by physics teachers in the classroom
10. I am now acquiring further knowledge of physics
11. I can now study and solve problems in physics on my own

    Why did you respond the way you did in the previous question?
12. I expect to perform well in other science subjects
13. I am able to work independently in physics exercises in and outside physics classrooms
14. I expect to score highly in physics tests.

    Why did you respond the way you did in the previous question?
15. I expect to be able to apply physics easily in other situations I life
16. I find learning physics is in itself rewarding
17. I am now satisfied with the way I learn physics.

    Why did you respond the way you did in the previous question?

18. I no longer feel uneasy during physics lessons
19. I am dissatisfied with my participation in classroom physics activities
20. I was satisfied with the way physics was taught in the classroom.

    Why did you respond the way you did in the previous question?
21. I am now satisfied with my performance in physics assignments and tests.

    Why did you respond the way you did in the previous question?
22. I now aspire to study science after high school.
23. I am not sure whether I have the desire to continue studying science.
24. I not find activities in physics lessons meaningful
25. I discover that physics subject matter is related to my daily experiences.
26. I realize that physics gives opportunities for choice, responsibility and inter-personal influence
27. Physics lessons give me opportunities for cooperation and social interaction.
28. I would like a career that does not require physics.

# APPENDIX F

# TEACHER GROWTH JOURNAL PROMPTS

1. What was one thing that went well today?

2. What was one thing that could have gone better today?

3. Where do you feel you could make improvements and how would you improve?

4. Provide an example of a student conversation in which they benefitted from mastery learning approach.