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Do learning logs have an impact on the conceptual mastery of force and motion?: subtitle

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DO LEARNING LOGS HAVE AN IMPACT ON THE CONCEPTUAL MASTERY OF FORCE AND MOTION?

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Abstract

This two-week study was conducted to investigate the impact Learning Logs have on student conceptual mastery of force, motion, and kinematics. To begin the study a sample of 554 ninth grade students were selected from a suburban public school in Louisiana. The students were randomly divided into experimental and control groups within four teachers' classrooms. This distribution was to examine the impact of Learning Logs regardless of the teaching style or time of day. Upon the study's conclusion there was no significant differences noted due to teaching style or time of day. The Force Motion Concept Evaluation (FMCE) was used to establish conceptual knowledge gained throughout the unit.

Further analysis of the data was done to see if other variables such as gender, ethnicity, economic status, or student learning exceptionalities had a significant impact on conceptual mastery. None of the aforementioned variables showed statistical significance. The students in this study did not make significant gains on the FMCE. The data showed that students stayed with their personal explanations regardless of the Learning Logs. Students appeared to have held onto their own explanation or an Aristotelian view despite the variables discussed. The persistence of student responses is greater than the random guessing threshold. Students were more likely select and maintain their misconception on the FMCE.

Introduction

Each year there is an increasing amount of pressure placed on teachers to incorporate new techniques into instruction by both the state of Louisiana and local school boards. At my research school site the push was to use Literacy Strategies in all classrooms kindergarten through twelfth grade. Literacy Strategies are designed to incorporate higher-order thinking skills as well as English/Language Arts skills, and to increase student-writing abilities in all academic areas. These strategies were first adopted by the Louisiana State Department of Education in June of 2008 (Louisiana Department of Education Grade Level Expectations). The school's administration selected Learning Logs as part of their mandatory school improvement process. The administration saw these tools as a means of helping Science students achieve the state's mandated goals for the required high stakes End of Course Exams. The idea of the Learning Log practice is centered upon students utilizing journaling to reflect on the science concepts and skills presented to them. Students are able to talk with their classmates or instructors through writing in the logs after collaboration or knowledge sharing with peers/instructors. The Louisiana Department of Education's website gives the following rationale for Learning Logs:

> A learning log is a notebook, binder, or some other repository that students maintain in order to record ideas, questions, reactions, and reflections, and to summarize newly learned content. Documenting ideas in a log about content being read and studied forces students to "put into words" what they know or do not know (Audet, Hichman, & Dobrynina, 1996). This process offers a reflection of understanding that can lead to further study and alternative learning paths (Baker, 2003). It combines writing and reading with content learning (McIntosh & Draper, 2001; Sanders, 1985). Learning logs can become the place for virtually any kind of content-focused writing (Brozo & Simpson, 2007).

To prepare for the use of this technique state wide, teachers were given two hours of professional development training in the late summer of 2009. Teachers were expected to implement the strategies immediately at their schools. Three years of Learning Log utilization would occur prior to this study's conduction. According to the Physical Science teachers, at the study school, the learning technique was difficult for them to grade. The grading process was often complicated due to the fact that responses to the prompts were very open to student interpretation. Over time, another variable surfaced which was due to the students' exposure and mastery of basic writing techniques. Because classes are composed of students at various learning levels (Regular Education, Special Education, 504, Retained Students, and Gifted Students), the challenge of meeting many different learning styles has further complicated instructional delivery. The school was unique in the fact that it only has a ninth grade population. The students come from three feeder schools and often have three very different instructional backgrounds.

After some student surveying, the teachers reported that none of the middle schools had used Learning Logs in their daily instruction. I began by looking at an analysis of the literature, which led to the state selecting this strategy. Were these studies cited beneficial in a high school Physical Science classroom? I also wanted to know how much of an impact Learning Logs had on students' conceptual mastery of Force, Motion, and Newtonian Physics. These G.L.E.s are the only exposure some students, in Louisiana, may get to Physics. The state no longer requires students to take Physics, so many will not see these G.L.E.s ever again.

A starting point in this process was to locate an operational definition of a Learning Log, research that analyzed its benefits or negative effects, and how valid the data this technique generated is in terms of assessing student mastery of knowledge. The term Learning Log is directly linked to an older concept previously referred to as "reflective journaling" or "journaling". (Henderson *et al.*, 2002) Henderson *et al.* stated "a major challenge teachers face when using reflective journaling, is how to address misconceptions without affecting the learners' motivation." During this process it is easy for a learner to make improper linkages to concepts that in many cases run contrary to the factual presentations before them. In numerous studies it has been shown that learners will cling to these misconceptions despite having opportunities to experience first hand the proper foundational knowledge (Henderson *et al.*, 2002; Fellows, 1994; Force Concept Inventory; Thornton *et al.* 1998; Okhee, 1993). It has also been demonstrated that by making learners come "into direct conflict with their misconceptions, new knowledge may begin to take root" (Hammer, 1996).

Cooperative learning models have also shown that the role of the instructor shifts from that of a direct lecturer and becomes more of a guide (Burron *et. al* 1993). When serving as a guide, the educator must avoid giving students knowledge directly, but instead focus on probing questions and exercises to provide opportunities for learners to bridge gaps in understanding. As the title of guide implies, the teacher must also make judgment free responses to redirect the learner when they stumble along the path to conceptual mastery (Lee*,* 1997). Learning Logs should therefore allow students to confront their misconceptions privately and with interaction from other learners. The Learning Log format provides for students a collaboration time. This allows for students

to use the information gained from class and peer-to-peer interactions as they construct their responses (Audet 1996).

It is clear from the prior studies that no isolated feature of writing garners a complete picture of a learner (Audet, 1996). English Language Arts teachers have long utilized the reflective journal to reinforce learning and reading comprehension (Lee, 1997). Lee used this idea to convey the basics of the use of the technique for any academic area. She explains the practice of a reflective journal as the teacher selecting a topic of study and designing questions that are appropriate to guiding students towards the desired conceptual mastery. Students will then proceed to use a journaling format to respond to the topic. The journal is read by peers and in some cases the teacher to check for student understanding. As each student reads the entry, feedback is given and the learner is afforded an opportunity to absorb the feedback as well as reflect upon its added educational value. The students are then able to respond, in writing, to the feedback solicited and in this process provide a window into their own conceptual grasp. The writing generated by each student will show a more in depth explanation of the individual's grasp of the concept. Students, when properly using this technique, can have a space to share ideas free of any judgments. Ideally these journals will aid students in exposing their thoughts without the uncomfortable worry of being labeled "incorrect". Through this indirect form of interaction a picture will emerge of the student's conceptual mastery. Teachers will be able to read each entry, examine each student's misconceptions, and use the feedback created by the entries to guide instruction (Baker 2003; Fellows, 1994; Lee, 1997; McIntosh *et al.,* 2001; Sanders, 1985).

At this point these “reflective journals” were suggested as a viable tool for mastering science concepts. The “reflective journal” maintains its function, but now bears a new name, the Learning Log (Audet, 1996; Baker, 2003; McIntosh *et al.*, 2001; Sanders, 1985). The students’ writings continued to be used as a tool for educator’s to gain insight into the students’ thinking pathways and new knowledge mastery. Now Learning Logs were also used to guide student knowledge mastery in procedural or conceptual ideas as well (Nussbaum *et al.,* 1982; Audet, 1996). For this methodology to properly work in a science classroom the potential source of student misconception must be addressed prior to the methodology’s utilization. Without the appropriate format for questioning and responding being used, by the teacher, the value of this method may become lost in a science classroom. In the setting of an English Language Arts classroom, questions are often framed in an open-ended manner relying more on student interpretation of a topic or literary work to begin the guided learning process (Lee 1997; Fellows 1994). In the scientific classroom however, open-ended response questions may afford learners the risk of further complicating new knowledge mastery. Learners may compound, reinforce, or completely misinterpret the proposed topic (Hammer, 1996; Burron *et al.,* 1993; Lee, 1993). To correct this potential source of initial confusion, it is feasible to use research based multiple-choice questions to begin the student’s foray into learning (Force Concept Inventory Simplified, Thornton *et al.* 1998). Students can still be guided to make a selection, but will also be provided space beneath the question to give feedback to the reader. When the process of using the previously mentioned “reflective journal” is merged with guidance a Learning Log is now established (Hammer, 1996; Sanders, 2010).

One of the main proponents of the Learning Log methodology, Nancy Fellows, has devoted a great deal of discussion to the methodologies' extensive use of writing to generate reflection on the concepts of science. Fellows argues that many past studies on understanding how students perceive science lack a "window" to individual student thinking (Fellows, 1994). This problem is further complicated by how the educator themselves approach the new instructional technique (Krajcik *et al.* 1994). Educational training practices, taught to educators themselves, have largely relied upon the methodology of direct instructional content delivery followed by limited guided practice and a brief amount of independent practice, which culminates into a summative assessment (Dart *et al.* 1991). The primary deficit in this instructional model is the lack of self-generated learner feedback. This model "does not tell us how students' knowledge has actually changed, how their thinking has developed, or how they themselves experience their learning" (Tynjala, 1998). Students often gain a better sense of self-generated understanding when they can rectify their self-imposed errors without fear of a grade or some other form of negative feedback (Hammer 1996). Mary Hanrahan abdicates that affirmational feedback will not only bolster student interest in science, but will make students more receptive to deeper levels of concept pursuit. Similarly, Hanrahan sees journaling responses as a way to assure that answers are not "judged on scientific orthodoxy or for orthographical or grammatical correctness" in order that students' answers are welcomed in the spirit of individuals having the "right to make sense of their own experience" (Hanrahan, 1999).

Elizabeth Lee sees that "an essential benefit of the learning response log is the creation of an environment where students feel free to express their concerns and

experiment." Lee was an English teacher who often saw weaker students attempt new explanations, be they correct or incorrect, more frequently in journal format. She saw these attempts at gaining new knowledge as experimental approaches by students as they sought conceptual understanding of the content. Lee describes in her research experiences where students developed a deeper rapport with her, which in turn led to them wanting to explain their work as opposed to merely seeking the right answer. Lee contends that higher-order thinking occurs from students explaining how an answer was achieved and not from simply completing a complex task. Additionally, Lee argues that Learning Logs promote a constructivist approach to learning with a greater emphasis on the student directing their interests (Lee, 1997).

Krajcik *et al.*, 1994 has also proposed the use of Learning Logs, not only to promote higher order reasoning skills in students, but also because they can have the same affect on educators. In a series of interviews of university professors conducted by Henderson, he found that many instructors believed student learning was directly impacted by their abilities to use peer/instructor feedback, working out and discussing physics problems, and by recording observations on an on-going basis. The interviews showed some discrepancies in the individual instructors' attitudes towards learning, but all agreed their courses and instructional methodologies were impacted by feedback from their students. Henderson, like Krajick, sees the use of the Learning Log as a dialogue or data gathering tool, which results in teachers beneficially redesigning their lessons and a better understanding of their students (Henderson *et al.* 2002; Krajick *et al.* 1994).

With all of the beneficial arguments for Learning Logs made, I began searching for the supporting empirical research generated on Learning Logs. The Louisiana State

Department of Education's website lists four studies as evidence for the Learning Log's application to Science (Audet 1996, Baker 2003, McIntosh *et al.* 2001, & Sanders 2010). Of the four studies referenced, only Audet utilized quantitative data to attempt to show some slight gains in student conceptual mastery. This study, which is currently the primary piece of supporting research, was not a true experimental study. The study was conducted without a true experimental design and was more of an analysis of a method after its implementation (Audet 1996; Louisiana Department of Education Website).

Audet's study focused on the educational effects of using computerized Learning Logs with a group of high school sophomore Physics students. The study utilized the format of a student and teacher dialogue in a digital journal over an eight-week unit. A comparison group from a previous year who did not use Learning Logs was used as the control. For this study, student's responses were scored using Kagen's qualitative scoring guide (Kagen, 1990). Within this qualitative framework, student responses were tracked and quantified to see if patterns of knowledge demonstration became more evident as the Learning Logs were utilized. The study had inconclusive results as far as knowledge gained due to several factors. The primary sources of error were a fundamental lack of empirical data, the data not being collected during the trial's conduction, and a lack of experimental design (Audet, 1996).

I think Audet attempted to analyze the knowledge gained by the students after the school year had concluded. Audet had not intended to study Learning Logs, but noticed some observances in his students' performance on a particular unit. He attempted to then retrospectively turn these observances into a study. This approach led to many questions on the exact variables that may have impacted the study's outcome. The responses that

were submitted by the students were in the format of open-ended responses. Due to this open format Audet was forced to score many students in a qualitative method. This disconnect in grading raised doubts as to the accuracy and fidelity of his empirical conclusions. The study cited no research with a proven methodology in scoring student responses. Audet's work did highlight the necessity of looking for a methodology to collect more empirical data or to utilize other methodologies to address some of the variables that were previously unaccounted for (Audet, 1996).

The next influential study on Learning Logs occurred in the United Kingdom. Stephens *et al.* sought to look at the five-week utilization of learning logs with a group of fourteen to fifteen year olds. This study sought to explore the questions of how Learning Logs contribute to student self-reflection and in turn lead to conceptual mastery. Unlike Audet's study this one did have an experimental design. Despite having a small sample size of 30 students and no control group, the study broached upon the idea of gathering empirical data via a questionnaire. The questionnaire, created by McLellan (McLellan, 2005), was used as a pre/post test to measure student gains. Students were asked to complete exercises, which were scored under a Wilcoxon scale. This scale correlated the students' mastery to a predetermined numerical value to assess whether their population mean ranks differ (Wilcoxon, 1945). Stephens *et al.* attempted to use a quantitative scale to score open-ended student responses. Once again a fundamental problem arose in the transference of qualitative data into empirical data. The experiment concluded that the format and time scale were inadequate for the experiment to garner any conclusive data. The standard deviation showed a clear case of non-clarity in the fact that pre and posttest scores were nearly identical. Stephens *et al.* suggested that other researchers might rectify

the data errors by narrowing the options students could answer with and focusing on specific topics that could be used in student responses (Stephens *et al.*, 2010).

Following the recommendations of the Stephens *et al.* study many other studies were conducted using learning logs. A study conducted by Barry Dart and John Clarke used the Learning Log itself as the primary data collection tool. A group of sixty-seven pre-service science teachers who were asked to use Learning Logs as a means of tracking their own responses to various teaching techniques. The pre-service teachers were asked to record their thoughts on the affect different lessons and labs had upon their learning motivation. There was no control group used for this study. The study's design allowed its participants to use learning groups, discussions within their groups, and independent research to master the course's objectives provided daily entries were made in Learning Logs. The Study Processes Questionnaire (SPQ) by Biggs was used as a pre and post quantitative assessment. The SPQ tests provided a narrower topic focus on a specific set of skills. While the empirical data generated from the questionnaire was promising, the lack of a control group raises questions as to the study's validity or true applicability. It was also difficult to see the rationale behind the numerical correlation assigned to the students' verbal scores due to a weak correlation in the SPQ's key with the actual data gathered from the Learning Log (Dart *et al*, 1991).

The Clarke and Dart study stated, "In their Learning Logs, students commented on their personal learning experiences. These were unstructured open-ended responses and provided qualitative data to both compliment and supplement the quantitative data" (Dart *et al*, 1991). While a great deal of discussion was made on the participant's comments the study never attempted to quantify or establish a concrete methodology for

numerically rating the responses. The study presented data that supported an overall growth in participant knowledge and stated that the majority of Learning Log entries showed a "favorable attitude directed towards reflection learning through the logs" (Dart *et al.* 1991). Dart's study made it clear that the use of Learning Logs as an assessment tool would require a more definitive scoring methodology.

The primary challenge of scoring Learning Log responses is clearly a major roadblock in this process. Promise for solving this problem came in a study by Burron *et al*, as they investigated the impact Learning Logs coupled with peer team interactions, had on students' attitudes towards learning Physical Science in a laboratory setting. They did have a control group, which used the traditional methodologies of lectures and independent work. Burron *et al.*'s study used a twelfth grade National Assessment of Educational Progress (NAEP) Science Exam as a pretest and post-test to track their participants' content knowledge. Unlike other studies Burron *et al.* also used the Instructional Strategies Evaluation (ISE) to "measure the students' perceptions of the relative strengths and weaknesses of cooperative learning" (Burron *et al.*, 1993). The data from the ISE displayed significant evidence in favor of cooperative learning and demonstrated in all but one subtopic a benefit from the proposed methodology. The methodology of the ISE as a research tool still relied heavily upon having Burron and his colleagues qualitatively analyze the open ended responses (Burron *et al.*, 1993).

To understand student thinking required investigation into what are the common ideas students share. A starting point in this process was an understanding of Aristotelian thinking. Aristotelian Physics uses the idea that motion is due to a change in position and requires set reference points. (Halloun, *et. al* 1985) While most of the ideas of

Aristotelian Physics would sync up with the data recorded it is important to note some discrepancies in student thought processes and true Aristotelian Physics. Halloun *et al.* points these out in the fact that while students may not think the Earth's surface is stationary (non-rotating) many would agree that heavier objects fall faster, an increase in speed must mean that there is an increase in force, movement only occurs with the application of a force, a constant force would lead to a constant increase in speed, and if no motion is occurring then no forces are applied to the object. Halloun *et al.*'s study was conducted to see the thought processes used; by first time college physics students, as they explained their thought processes on a series of questions. The outcome of Halloun *et al* suggested that students were not using only Aristotelian Physics but a combination of personal observations, misconceptions, life experiences, and Aristotelian ideas. The study's suggestions that students' personal ideas are often difficult to completely explain, but must be considered when designing experimental exams.

Methodology

Study Format

It is clear that in order to create a proper study, I need to design a method of empirically measuring student conceptual mastery as well as assessing the portion of the student's qualitative responses. I began by selecting a study school that would afford the maximum data yield. A ninth grade academy was chosen since it is both the first exposure many students have to Physical Science and it has a cohort with a n=554. I looked at the format of Audet's study to construct a rough framework. I started by designing the Learning Log to collect data from a very narrow set of objectives.

For guidance in selecting an appropriate set of objectives I used the Louisiana Department of Education's Grade Level Expectations (G.L.E.s) for Physical Science. The G.L.E.s are used state wide to ensure that all students are receiving the content in a semi-standardized way. Each parish is permitted to develop their own methodology for tracking teachers as they use the G.L.E.s to guide their teaching (Louisiana Department of Education Grade Level Expectations for Physical Science). In the study school the faculty are required to follow a parish developed pacing guide. A parish-selected team of teachers made the pacing guide, which was developed by a team of veteran Physical Science teachers. This team met for four hours in 2008 and set the weekly objective mastery goals. The parish's policy permitted teachers to be either two days ahead or behind of the preset goals. If a teacher were outside of this guideline they would face disciplinary action by their principal. Under this framework the G.L.E.'s for Newton's laws of force and motion were allotted two weeks in the second semester. The objectives

from the Louisiana Department of Education Grade Level Expectations for Physical Science were:

1. Measure the physical properties of different forms of matter in metric system units (e.g., length, mass, volume, temperature) (PS-H-A1)
2. Gather and organize data in charts, tables, and graphs (PS-H-A1)
3. Differentiate between *mass* and *weight* (PS-H-E1)
4. Compare the characteristics and strengths of forces in nature (e.g., gravitational, electrical, magnetic, nuclear) (PS-H-E1)
5. Differentiate between speed and velocity (PS-H-E2)
6. Plot and compare line graphs of acceleration and velocity (PS-H-E2)
7. Calculate velocity and acceleration using equations (PS-H-E2)
8. Demonstrate Newton's three laws of motion (e.g., inertia, net force using F = ma, equal and opposite forces) (PS-H-E3)
9. Describe and demonstrate the motion of common objects in terms of the position of the observer (PS-H-E4)
10. Model and explain how momentum is conserved during collisions (PS-H-F2)

(Louisiana Department of Education's Grade Level Expectations for Physical Science)

A total of five hundred and fifty instructional minutes were needed to cover these topics. The study's focus was now centered on the conceptual mastery of force, motion, and newton's three laws, which needed to occur in this time period. With a clear focus on the student learning objectives selected an empirically accurate means of scoring student responses was necessary. The Force Motion Concept Evaluation (FMCE) provided research proven method of assessing student knowledge that was free of subjective influences. The FMCE is a forty-seven question multiple-choice formatted exam. The FMCE has been used on students at this grade level many times and is considered to be a reliable assessment of conceptual learning (Thornton *et al.,* 1998). The exam dedicated six questions to Newton's First Law, fifteen questions to Newton's Second Law, ten questions to Newton's Third Law, and twelve questions to Kinematics. The exam offered five to seven responses for students to choose from on each question. The FMCE was

utilized as a pre and post-test of student conceptual mastery in my study with permission form Robert Thornton at Tufts University (Thornton *et al.,* 1998).

In designing the Learning Log implementation I relied upon the procedure used in Stephens *et al*'s study. Stephens *et al* used learning logs for lab reflection on very specific techniques and concepts in the United Kingdom. The study generated no discernable difference in its pretest or post-test scores due to data errors resulting from students having too broad of a response field. The study recommended a narrowing of the options and topics that students could use in their responses. I proceeded to do this through the design of multiple-choice questions with a space for free response provided.

To clarify the issue of seeing if students were gaining knowledge from their own self-analysis of their work, I began looking at aligning the Learning Log questions to the prescribed lesson cycle. To accomplish alignment a sequence of prior year's lessons was analyzed from each of the study's participating teachers. After this review was completed, a series of multiple-choice questions was generated for use on each day. The questions were structured similar to the FMCE and would provide a means of empirically tracking the students' daily conceptual knowledge, regardless of their use of reflection. Below is a sample Learning Log question that I created, a complete set of questions used is shown in Appendix B.

Week 1 Day 2: You toss a ball up into the air. Which of these statements is true of the ball as it is going up into the air?

A. the force of gravity > the force the ball is tossed up with
B. the force of gravity = the force that the ball is tossed up with
C. the force of gravity < the force the ball is tossed up with
D. gravity is the only force acting on the ball
E. there is not enough information provided to answer this question

Figure 1: Sample Learning Log question used during the study

With the format of the Learning Log selected it was now time to find a mechanism of incorporating a place for students to show reflection. It was important to note that the study's focus was on the actual use of reflection by the student and not necessarily a "correct" expression of the reflection. For this purpose I decided to score the reflection on a basis of whether a student attempted to respond or not. An attempt at reflection would receive a score of one and no attempt would yield a student score of zero. I chose to incorporate a place for reflection as shown in Figure 2.

Week 1 Day 2: You toss a ball up into the air. Which of these statements is true of the ball as it is going up into the air?

A. the force of gravity > the force the ball is tossed up with
B. the force of gravity = the force that the ball is tossed up with
C. the force of gravity < the force the ball is tossed up with
D. gravity is the only force acting on the ball
E. there is not enough information provided to answer this question

Did you change your answer from the start of class? Yes No

If yes explain why:____

Figure 2: Sample Learning Log, with space for reflection, used in this study.

Participants/Implementation

The Learning Logs were administered daily for a ten day period. The students were divided, by class section, into either an experimental or control group. The entire class section would be given either a control or experimental question each day. (A discussion of the actual procedure used in these sections is explained further in this paper.) Each teacher taught either four or six sections of Physical Science. All class sections were composed of randomly assembled numbers of sub groups, which are listed in Tables 1 and 2. The study school had a large 9th grade population above 500 students, with all but two groups taking Physical Science. Of the students who did not take

Physical Science forty-six were taking Biology only and twenty were self-contained non-diploma bound special education students. The forty-six Biology students were simply taking Biology by choice instead of Physical Science. This study included five hundred and fifty four students. These students were divided amongst the four teachers in twenty sections. The target population had five hundred and twenty eight students (85%) who qualified for free/reduced lunch and was composed of three hundred and forty one male (55%) and two hundred and seventy nine female students (45%).

Table 1: School wide ethnic groups reflective of trends

Racial Groups	%
Caucasian	Above 80%
African American	Less than 10%
Hispanic	Less than 10%
Asian	Less than 10%

Table 2: School wide sub groups reflective of trends

Educational Groups	%
504	Less than 10%
Gifted	Less than 10%
Special Education	Greater than 10%

All students were given the FMCE prior to the two-week unit being taught. After the pretest was given there was a slight difference in the activities carried out in each class section. The study school utilized a start of class activity called a "bell ringer" as a

means of getting students to enter the room and get settled. These "bell ringers" were for a daily grade and a key part of the students daily routine. The "bell ringers" were typically open-ended questions as seen in Figure 3.

What is Newton's First Law? Give an example from yesterday's notes.

Figure 3: A sample "bell ringer" question.

Using this school-wide system, the Learning Log was substituted for the "bell ringer". Teachers were given the Learning Log questions copied and sorted by section prior to starting the study. In the control sections the teachers allowed for students to work on the Learning Log question, such as the example in Figure 1, for five minutes and before it was collected. In the experimental sections students kept their Learning Log slips until the end of class. Five minutes prior to the end of class students in the experimental classes were asked to turn their slip over. Students were presented with the exact same question as the start of the class but with a probing question as seen in Figure 2. Students were given permission and time to interact with their peers seated near them. Their responses on the end of class question afforded them a chance to explain their reasoning. Each student had the opportunity to converse with other learners, record their thoughts, make corrections to errors in their answers and resubmit the new response if they chose. The FMCE posttest was given at the end of the two-week unit to assess conceptual mastery. Upon the study's conclusion one hundred and fifty four students had to be removed due to a lack of a pre or post-test.

The remaining student demographics for the groups are listed in Tables 3, 4, 5 and 6. Tables 3 and 4 are for the control group. There were one hundred and ninety eight total students in the control group. The control had one hundred and four students (53%) who

qualify for free/reduced lunch. The control had ninety-two Males (46%) and one hundred and six Females (54%) as participants. Tables 5 and 6 are for the experimental group. There were two hundred and two total students in the experimental group. The group had one hundred and three students (53%) who qualify for free/reduced lunch. The control had one hundred and two Males (55%) and ninety Females as participants (45%). The only significant difference in the targeted population's make up and the actual study was the percentage of free and reduced lunch students. It is unclear as to what impact this may have had on the study's data.

Table 3: Control study group's ethnic groups

Con. Racial Groups	**Number**	**%**
Caucasian	172	86.8%
African American	22	11.1%
Hispanic	9	2%
Asian	1	< 1%

Table 4: Control study group's sub groups

Con. Educational Groups	**Number**	**%**
504	4	2%
Gifted	7	3.5%
Special Education	17	8.5%

Table 5: Experimental study group's ethnic groups

Exp. Racial Groups	Number	%
Caucasian	164	81%
African American	21	10%
Hispanic	11	5%
Asian	2	< 1%

Table 6: Control study group's sub groups

Exp. Educational Groups	Number	%
504	4	1.9%
Gifted	6	2.9%
Special Education	14	6.9%

The teachers participating in this study were all experienced teachers within their field. For the purpose of data collection the teachers were randomly assigned a code T1, T2, T3, or T4.This system will be used for data tracking in this study. All four were certified by the state of Louisiana, met the definition of the national requirement to be highly qualified in the area of Physical Science, and had taught the content for at least two consecutive years using the local parish's pacing guide. While each teacher was allowed to structure their content delivery cycle in their own manner, they also had to follow the previously discussed parish and state guidelines. All teachers had access to the same textbooks, teacher resources, lab equipment, visual aids, demonstration tools, and

educational videos. All four teachers were present for the entire two week study and taught their students for two FMCE administration periods and ten forty-five minute class sessions.

Results/Analysis

Preliminary Analysis

Upon collection of the data the FMCE was scored using the accepted key and data, was recorded as discussed in Appendix A. The average mean of the control and experimental groups pre and post-tests was calculated. The uncertainty of the mean showed no difference in the pretest scores, but the data showed a very small visible difference between the post-test data.

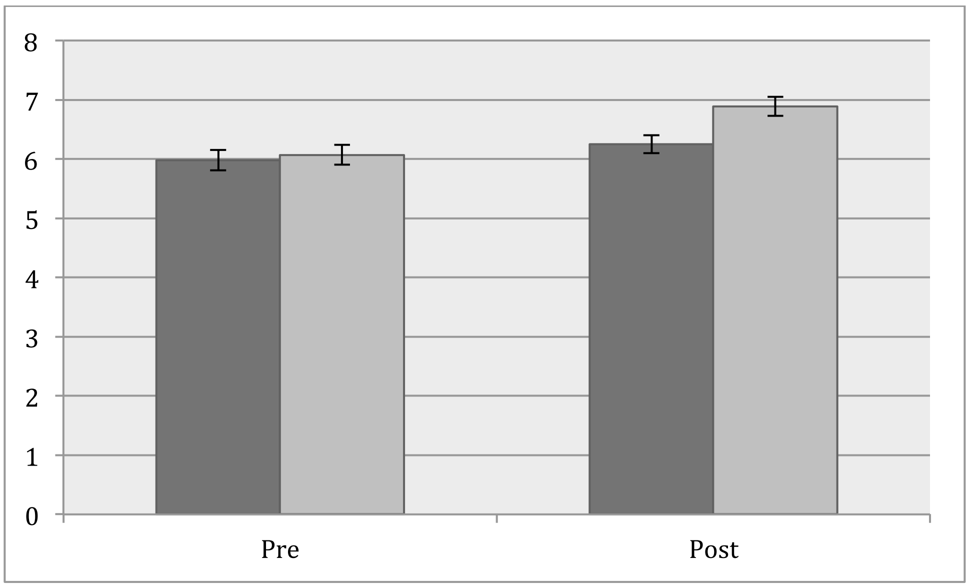


Figure 4: The mean of the pretest and post-test values for the experimental (dark gray) and control (light gray) groups. For the control N=197 and for the experimental N=203. There were 47 questions on the FMCE.

A two-sample t test was conducted to establish whether the data between control and experimental groups were statistically different. The alpha value of 0.05 will be used to aid in confidence calculations here and throughout the study. The error bars depicted show standard error of the means here and throughout the study. The t test yielded a value of 0.1. This indicated that there was no real significance, but the results are more likely due to random chance.

Equation 1: t test

$$p\ value = \frac{\bar{X}-\bar{Y}}{\sqrt{\frac{\sigma x^2}{n_X}+\frac{\sigma y^2}{n_Y}}}$$

At this juncture in the data analysis an examination of the actual raw gains was conducted. This statistical test showed no significant difference due to an uncertainty of the mean of 0.17. To further examine the data from the gains a Normalized Gain (*g*), as shown in Equation 2, was calculated. The Normalized Gain reflects the fraction of the available improvement attained between the pretest and post-test.

Once again no significant difference was observed due to the uncertainty of the mean being 0.16.

Equation 2: Normalized Gains

$$g = \frac{posttest - pretest}{47 - pretest}$$

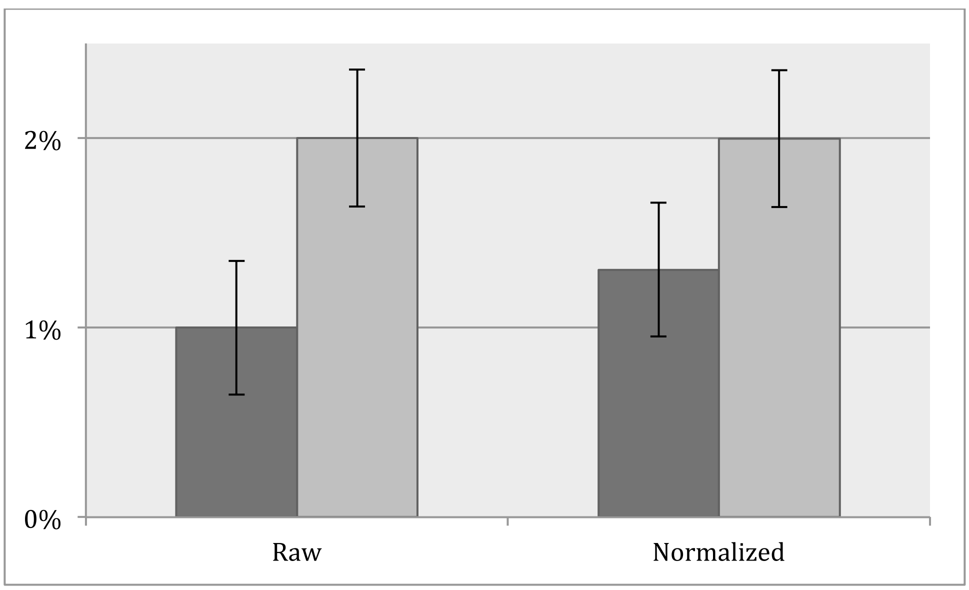


Figure 5: Raw Gains for the control and experimental groups. Control is shown in dark gray with an N of 197. Experimental is in light gray with a N of 203. Normalized Gains for the control and experimental groups.

With no clear significance in the prior analyses, an examination of the possible variations in genders was conducted using the t test. The data once again showed no significance in any of the possible comparisons, as seen in Table 7 and Figure 6.

Table 7: The t test values for the various groupings of males and females. Due to the fact that no values are less than 0.05 there is no significance in the groups.

Gender	Pre Test	Post Test
Male Experimental Vs. Male Control	0.65	0.16
Female Experimental Vs. Female Control	0.78	0.47
Male Control Vs. Female Control	0.90	0.57
Male Experimental Vs. Female Experimental	0.79	0.81
All Male Vs. All Female	0.69	0.91

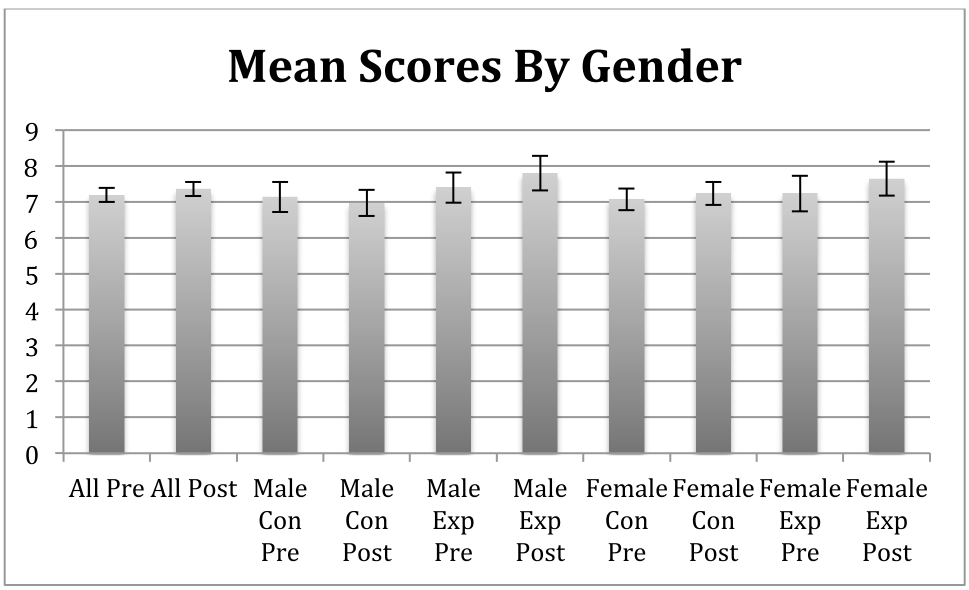


Figure 6: The mean scores on the pretest and post-test for the control and experimental groups broken down by gender. The uncertainty of the mean values are shown. Due to overlap in the error bars it is clear that there is no significant differences.

The analysis of the subgroups was then conducted using the analysis of variance (ANOVA). The ANOVA fixed effects model was selected as a means of measuring the possible change in the usage of Learning Logs between groups. The ANOVA test showed a p value of 0.34 between the various ethnic subgroups pretests and post-tests (African American, Asian, Caucasian, and Hispanic). There was a not significant effect on the population due to ethnic group as seen with a $p > 0.05$ for eight conditions [$F(3, 453) = 0.20$, $p = 0.26$]. The p value between the educational subgroups (Special Education, Gifted, Free/Reduced Lunch, and 504) was 0.70. There was not a significant effect on the population due to sub-group as seen with a $p > 0.05$ for eight conditions [$F(7, 276) = 0.65$, $p = 0.70$]. Each of the aforementioned data analysis methods yielded little evidence of the students making conceptual gains. A more in depth analysis of the data was merited.

Learning Log Impact

The Learning Logs for the control groups were scored using a correct answer key for the multiple-choice format (Figure 1). The experimental groups' were empirically scored as well, but students within this group were also scored for their use of reflection on a scale of one to zero (Figure 2). Students earned a one for making some attempt at writing a qualitative response. When the experimental data was analyzed, there were two thousand and twenty opportunities for student reflection. Of the opportunities available reflection was used a total of fifty-one times. The data showed that reflection was used only two percent of the total possible opportunities (Figure 7).

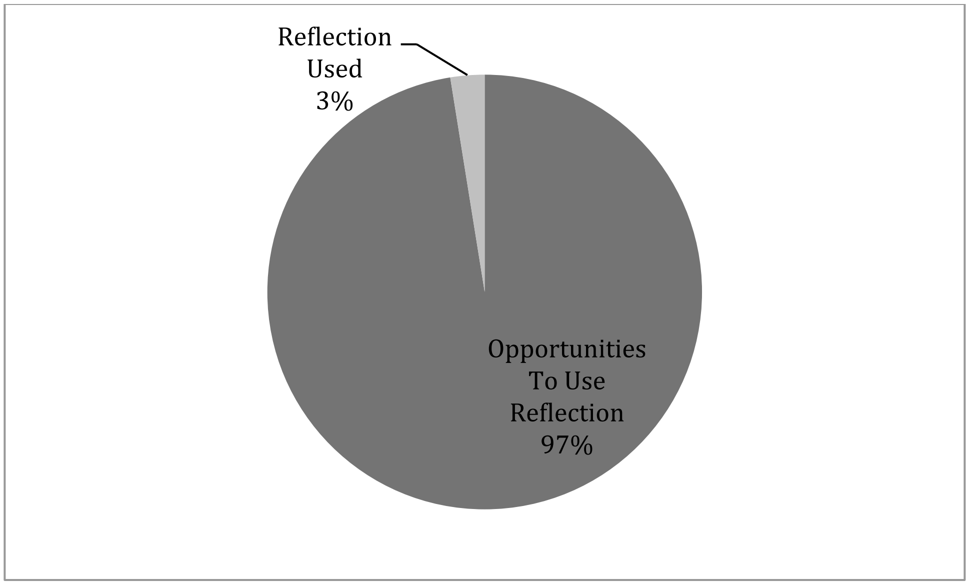


Figure 7: Pi chart showing the percentage that used reflection out of the total number of reflection opportunities.

The reflection opportunities for the fifty-one responses was then examined to see if the reflection contributed to the student properly selecting a correct response on the end of class question. The data showed that only two of the fifty-one responses resulted in the student moving to the correct answer. In the forty-nine other response situations students did change their responses to another incorrect response. It was also noted that only two participants in all of the experimental groups used the reflection space more than once. Of the two respondents to use reflection more than twice, one wrote nonsensical statements about “waffles”. All of the reflection responses were in an incomplete sentence format.

I was able to visit the teachers’ classrooms through out the study for ten to fifteen minute intervals. During three of these visitations I was able to observe the experimental group’s final five minutes of class. During this time the qualitative view of students would appear to be consistent with the numerous background studies’ findings. I observed students having conversations about the problems, some simply marking an

answer to turn in, and out of the ninety students observed only one appeared to take an extended amount of time (roughly four minutes) to reflect and write a response. If I had not empirically scored the Learning Logs and the reflection opportunities I would have agreed that the practice appeared to foster more student interactions. However, when comparing this empirical data to that of the prior analyses of the FMCE data it did not appear to be any discernible impact due to the Learning Log.

Focused Analysis

To obtain further insight on the students' knowledge an examination of the average student score on the pre and post-test was conducted for each of the four teachers data sets. The analysis grouped the control and experimental groups into one set of pre and post-test data (Figure 8).

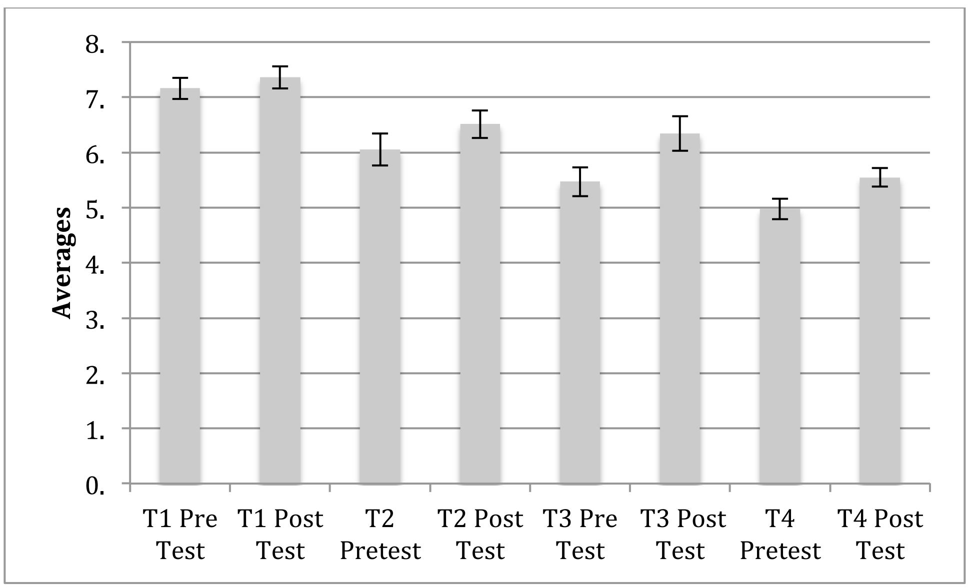


Figure 8: The average number of correct responses out of 47 questions.
This graph groups all of the students by teacher. The control and experimental students are graphed together.

From a series of random visitations I conducted and review of their lesson plans I could see that each teacher did try different methods. The visitations totaled twenty in

number and were throughout the sections each teacher taught. I visited each teacher five times and observed the practices for approximately ten to fifteen minutes. The teachers were all observed at the start and end of their lessons. One teacher, T4, was predominantly lecture based and relied heavily on the textbook resources to guide learning opportunities for the students. Another teacher, T1, was very lab and inquiry based in their instruction. The lessons had a thought provoking incident, demonstration, or example used as a catalyst to begin the day's lesson. Students were given a brief lecture but often class discussion and peer-to-peer interactions guided class. The remaining teachers, T3 and T4, relied upon a hybrid of the previous teachers' methods. Students in these groups conducted three labs, relied mainly on lecture to receive content, but did have two discussion prompts.

The data from each teacher's sections display no real significance, but it did raise the question of what impact the teacher's teaching style did have on student gains. I looked at the correlation of the teacher's class FMCE score to their students (Table 8). The data showed that the teachers' style did not appear to have an impact on the mastery of the concepts. When the class average post-test scores were compared to each other the gains were of a non-significant statistical difference. Despite the varied teaching styles, the gains made by students were so minimal that it is clear that no delivery method was extremely effective. Students did not appear to master the concepts whether they were presented with labs, lecture, or discussions. I think that in future studies would be useful to analyze the role of the teacher's personal content knowledge understanding on student gains. It is possible that the teachers in this study were working with their own personal

ideas and that those may have factored into student understanding. This study did not focus on the teachers and therefore it is difficult to make a clear determination on this.

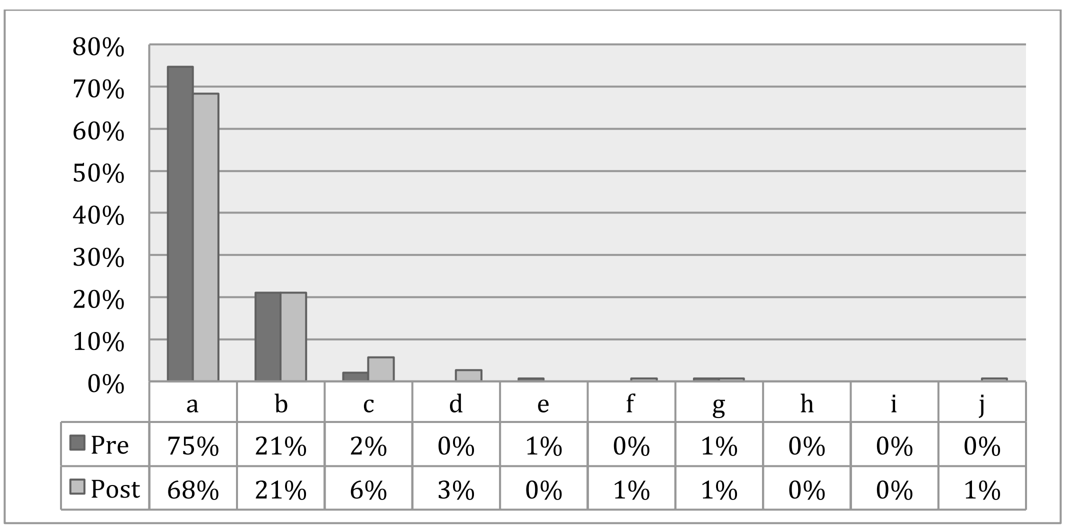
Table 8: This shows the students' correct percentage on the 47 questions of the FMCE in comparison to the average students' scores in other teacher's cohorts. The average student scores were a composite of the experimental and control group.

Teacher	Sample Size	Average Student's Pre-score	Uncertainty	Average Student's Post Score	Uncertainty
T1	N= 140	15%	+/- 1%	15%	+/- 1%
T2	N=74	12%	+/- 1%	13%	+/- 1%
T3	N=66	11%	+/- 1%	14%	+/- 1%
T4	N=120	10%	+/- 1%	12%	+/- 1%

When looking at the average score data it became apparent that very little was gained conceptually in the two-week instructional cycle. Using the simple probability of guessing the correct answer on each question the students should have had a score of 7 correct questions (13%), with a standard deviation of +/- 1%. It now became a point of interest to see what students were selecting for their answers and to attempt to gain insight into their misconceptions. It was also worth investigating whether students were persistent in their pre/post misconceptions.

The first step that was taken to narrow the data analysis process was to select one teacher's data to examine in detail. Teacher one's (T1) data was selected because it had the largest population (N=140) to work with. Since the prior data treatments had demonstrated no significance in the differences between control, experimental, gender, ethnicity, or academic subgroup the data was now treated as one set. The examination of misconceptions began by taking the T1 data and comparing the individual questions' answer choice selection percentage for both the pretest and post-test. An example of this form of analysis is shown with FMCE question 1 in Figure 8. The data showed that

students were gravitating towards at least one misconception more than others (Table 9). When looking at Figure 8, it is noticeable that a slight movement away from choice A is occurring by 6% of the students. The 6% movement was analyzed in Figure 9. Figure 9 shows a net movement of students from the Aristotelian answer to the other misconception choices. It does not show a student migration towards the Newtonian answers. The trend that was highlighted in question one from the T1 data was repeated in all but three questions of the students' data. Students were fluctuating in their responses on the pretest to post-test but they were not migrating to the Newtonian answer.The three questions that did not fit this trend involved students selecting the correct answer 58% to 76% of the time on the pretest and maintaining that percentage or increasing it on the post-test. This may indicate that students are taking this test with a desire to answer the questions correctly. When these three questions were cross-referenced, with other studies, it was clear that there was a high persistence for respondents answering them correctly (Thornton *et al.* 1998).



	a	b	c	d	e	f	g	h	i	j
Pre	75%	21%	2%	0%	1%	0%	1%	0%	0%	0%
Post	68%	21%	6%	3%	0%	1%	1%	0%	0%	1%

Figure 8: This chart shows the percentage of students for each answer choice on number one from the FMCE. The correct answer was choice b. A majority of the students are gravitating to choice a.

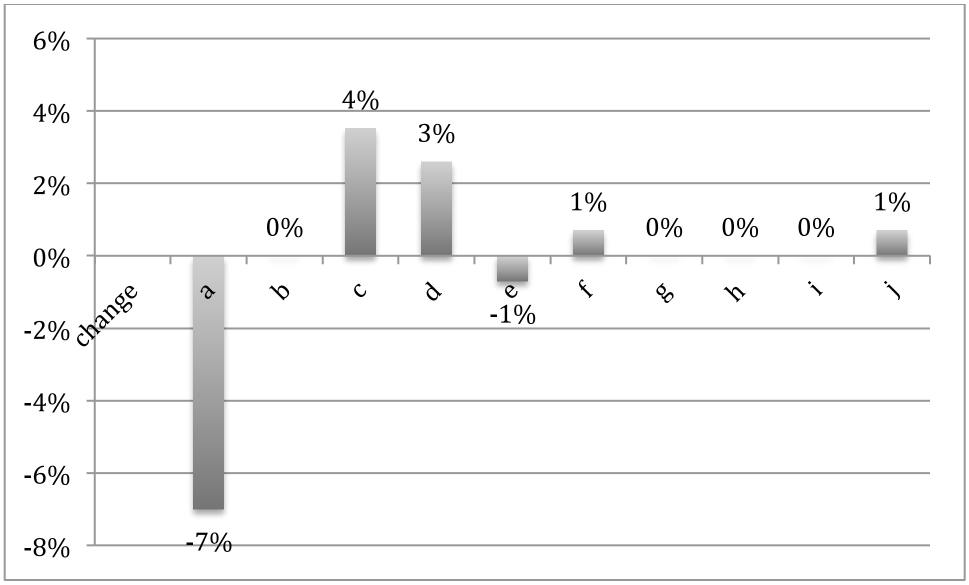


Figure 9: The percentage of students who moved away from the selected choices on their pretest for question 1 is shown here. While 7% migrate from choice a they are not moving towards the correct answer choice b.

This reoccurring trend was an area that required an in depth analysis of the answer choices and student's reasoning in selecting them. This process began by looking at the individual participant's selection of misconception answers and how frequently the individual changed their response. The data showed a strong correlation to one of three distinct thought processes Newtonian Physics, Aristotelian Physics, and Personal Ideas based upon life experiences. Three questions showed the Newtonian Physics logic as the predominant factor in answer choice selection (See Figure 10). Thornton et al. also noted these same three questions as being strongly answered with Newtonian Physics in the FMCE study. The students' personal ideas accounted for fifteen questions (See Figure 11). These personal ideas appeared to not fit either an Aristotelian or Newtonian definition, but did show a high percentage of selection by a greater than random guessing percentage of students. It is however, important to note that no exit interviews were conducted with the students so an exact explanation of the reasoning cannot be made. A misconception or student generated idea key was created by taking each question's most

selected incorrect answer. This Misconception key would be the basis for an in depth analysis method discussed further in this study. Aristotelian Physics appeared to be the guiding logic for twenty-nine questions (See Figure 12). The fact became apparent that many students were selecting and maintaining their personal ideas and misconceptions on both the pretest and the post-test. It was now necessary to investigate if this was with true persistence on the part of the students or random guessing.

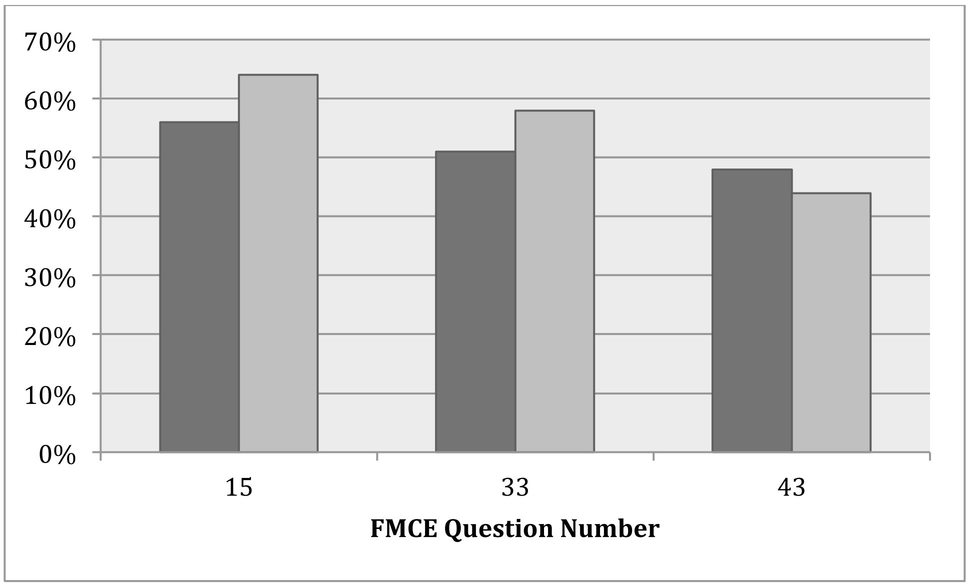


Figure 10: This shows the number of responses that had a statistical significance in terms of students providing an large percentage of correct responses. In dark gray the pretest is shown and the post-test is in light gray. The total sample was 140 students.

Trends became apparent by graphing the probability distribution of the percentage of students' selecting the same answer choice pretest versus post-test. An analysis of the kurtosis could be examined for each graph. The kurtosis is a measure of the "peakedness"

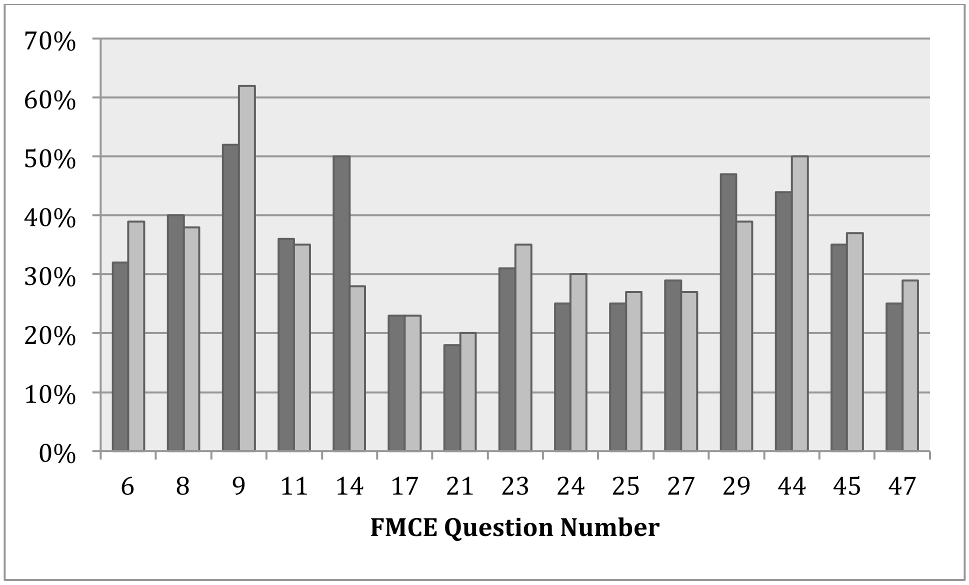


Figure 11: This shows the responses that were answered incorrectly by students in the group T1. Students maintained the same answer choice, which did not follow the Newtonian or Aristotelian logic. In dark gray the pretest is shown and the post-test is in light gray. The total sample was 140 students.

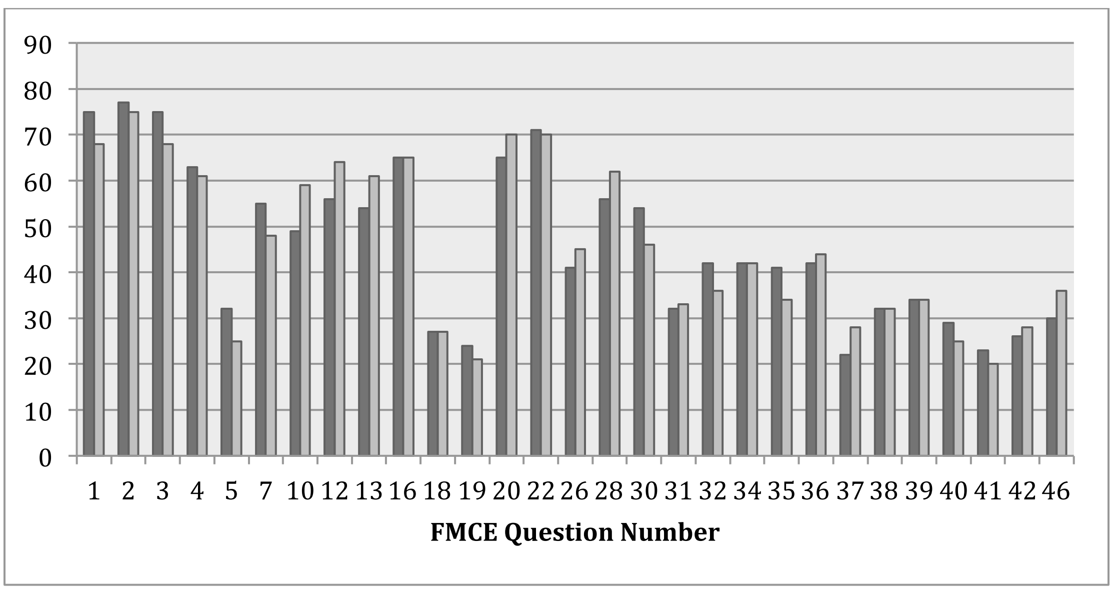


Figure 12: This shows the responses where the same Aristotelian choice was selected and maintained. In dark gray the pretest is shown and the post-test is in light gray. The total sample was 140 students.

of the probability curve. In a Gaussian distribution the narrower the bell curve is the greater the kurtosis. This suggested a great significance as to the students' responses being due to purposeful selection on the students' part. For the three questions where the

students selected the correct answer was leptokurtic with a 33% Gaussian distribution This made it clear that on the three questions where a majority of the students responded correctly, it was due to a purposeful selection.

The primary focus of the student persistence on the remaining forty-four questions showing incorrect answers were not as certain in their selection due to Aristotelian Physics. Taking the data from the questions and then conducting a Chi Square Analysis created a clear correlation of student persistence in students selecting an incorrect answer on the pre-test and maintaining it on the posttest, as seen in Figure 14. A Chi Square Test is used to compare observed data with data that is typically expected due to a given hypothesis or situation (Arken *et al.* 2005).

Equation 3: The Chi Square Test

$$X^2 = \sum \frac{(observed\ frequencies\ moving\ to\ a\ concept - expected\ frequencies\ moving\ to\ a\ concept)^2}{expected\ frequenciesmoving\ to\ a\ concept}$$

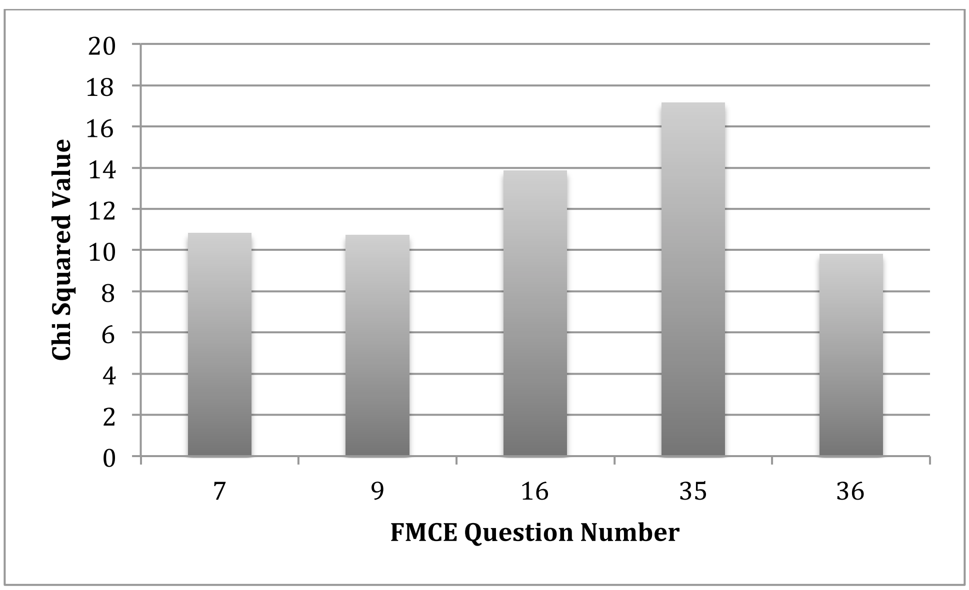


Figure 14: Chi Squared graph of the five questions answered with persistence using the Misconception key. By conducting a Chi Square analysis the data showed that 14% were maintaining their misconception with high persistence. This gives credence to the idea that there is not purposeful selection using purely Aristotelian Physics.

The data shows that students maintained their own ideas regardless of whether they selected their own ideas, Newtonian, or Aristotelian reasoning. Calculating the Chi Square for each student and comparing it with the accepted Chi Square table value of 9.48 found a correlation of 14%. The 9.48 value was selected due to there being four degrees of freedom and corresponds to a p-value of 0.05. Students held very firmly to their personal ideas on forty-three out of the forty-seven questions. It is quite clear that students were not randomly selecting answers, but felt there was fidelity in their reasoning. This firmness of choice selection held true for both the experimental and control students in the T1 study group.

Conclusions

The data that I collected led me into a series of investigations that I had not previously expected. The study itself set out to see the potential impact of one specific teaching technique, but opened up a very broad and essential area for further study. I think that after examining the students' data on Learning Log utilization and its impact on their conceptual mastery it is clear that the strategy fails to deliver any meaningful impact on force/motion conceptual mastery. Very few students used the technique and often those who did moved from the incorrect answer they selected at the start of the class to another incorrect answer. In the course of examining the FMCE data I found that students were holding firm to their ideas regardless of whether they were correct or incorrect.

The fact that students held firm to their personal ideas despite having four different teachers, using different teaching methodologies suggests that there is a great need for further exploration on why students are not mastering the concepts. The four teachers were all dedicated to their careers and through all available assessments of them were qualified and motivated to teach their students. In looking at the format of the concepts being taught and the time period that these teachers had to instruct it is questionable as to whether or not the time constraints impacted student learning.

The teachers had five hundred and fifty minutes to cover ten G.L.E. s, which means that the teachers had approximately one day to cover each topic and to also find the means to continuously review the prior days' topics. I cannot help but note that given the nature of this introductory course many students and teachers may be overwhelmed by the need to cover so much content in so little time. I also think that with a ten day

instructional cycle there would be very few opportunities for the teacher to grade an entire cohorts' papers, reflect on each, and provide detailed feedback to increase the individual student's conceptual mastery.

When I first looked at the data from the FMCE I thought that a lack of student motivation had impacted the results. As I began to see patterns arise from the data and the analysis I feel confident in saying that students were genuinely making a concentrated effort. The students appeared to believe in their answers so firmly that even when they did move away from them it was often to another incorrect answer, which incorporated a portion of their original answer or held similarity to their original pretest response. This made me wonder if there is a larger process at play in how students face their misconceptions. Are students able to go immediately from the incorrect answer to the correct one or is it more of a progression from incorrect to incorrect before arriving at the correct? I was also unable to answer the question of when and where students make false linkages in content. If a false linkage is made then what must occur to challenge the linkage sufficiently to make a student accept and internalize the correct answer? With students holding on to their personal ideas fourteen percent of the time it was not possible to see the possible progression in this study.

I think that another interesting question raised by this study was what impact does the teacher's knowledge of the content area and their selections of teaching methods have on student gains? In this study there was no in-depth analysis of the teacher's background in the content area or the teacher's own familiarity with the concepts that were being instructed. It would be of interest to collect more data on this in future studies. I was also

not able to examine the conceptual approach that the teachers in this study used to convey the information on the G.L.E.S. to students.

I think that this study has shown that minor changes in curriculum or simply using a new teaching tool that is not first empirically proven, will not create student gains. If we are to increase the conceptual mastery of students I do think that more investigations must be done on effective teaching strategies and methods. Students' personal ideas must be acknowledged, addressed, and challenged in order for new knowledge to be gained. The data from this study shows that students will not give up an idea in a short period of time. More research needs to be conducted to answer the over arching question of why students do not accept the Newtonian explanation and to see if the migration from a personal idea to the correct answer is a process. Time should be devoted to tracking students as they take new content and work it into their own personal ideas. An interesting study could easily develop on trying to see what factors would best facilitate conceptual transformation in the students.

The data collected from the FMCE displayed that students were not relying upon random guessing to answer questions. Students appeared to narrow their answer choice range to two or three choices depending on the question. Students clearly showed a lack of selection preference for a Newtonian answer. In many questions the students were demonstrating persistence to a choice despite two weeks on instruction.

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Appendix A T1 FMCE % Changes

This table shows T1's percentage change between pretest and post-test for each of the 47 FMCE questions. The correct answer choice is in light gray. The incorrect choice, receiving the most selections, is in dark gray

Choice	1 Pre	1 Post	2 Pre	2 Post	3 Pre	3 Post
a	75%	68%	6%	7%	2%	6%
b	21%	21%	77%	75%	1%	6%
c	2%	6%	6%	8%	75%	68%
d	0%	3%	7%	5%	6%	7%
e	1%	0%	1%	1%	6%	4%
f	0%	1%	2%	4%	7%	5%
g	1%	1%	1%	1%	1%	4%
h	0%	0%	0%	0%	0%	0%
i	0%	0%	0%	0%	0%	0%
j	0%	1%	0%	0%	1%	0%

Choice	4 Pre	4 Post	5 Pre	5 Post	6 Pre	6 Post
a	5%	4%	6%	6%	5%	4%
b	1%	3%	32%	32%	3%	4%
c	2%	4%	3%	2%	32%	39%
d	1%	3%	19%	23%	21%	12%
e	6%	8%	4%	5%	20%	21%
f	20%	18%	21%	25%	7%	8%
g	63%	61%	11%	4%	5%	12%
h	0%	1%	0%	0%	0%	0%
i	0%	0%	0%	0%	0%	0%
j	0%	0%	4%	1%	6%	0%

(Table Continued)

Choice	7 Pre	7 Post	8 Pre	8 Post	9 Pre	9 Post
a	2%	5%	5%	6%	4%	6%
b	2%	6%	4%	11%	8%	8%
c	5%	3%	2%	3%	3%	6%
d	12%	8%	6%	5%	52%	62%
e	55%	48%	15%	11%	13%	8%
f	13%	16%	40%	38%	8%	4%
g	9%	13%	25%	25%	6%	1%
h	0%	1%	0%	0%	0%	0%
i	0%	0%	0%	0%	0%	0%
j	1%	0%	2%	1%	5%	0%

Choice	10 Pre	10 Post	11 Pre	11 Post	12 Pre	12 Post
a	18%	15%	4%	4%	4%	5%
b	59%	49%	4%	8%	8%	4%
c	10%	17%	5%	6%	2%	4%
d	5%	6%	4%	3%	56%	64%
e	1%	4%	22%	19%	15%	10%
f	1%	2%	36%	35%	6%	4%
g	4%	5%	23%	24%	6%	4%
h	1%	1%	0%	0%	0%	0%
i	0%	0%	0%	0%	0%	0%
j	1%	1%	1%	1%	2%	1%

Choice	13 Pre	13 Post	14 Pre	14 Post	15 Pre	15 Post
a	15%	16%	50%	46%	11%	10%
b	61%	54%	5%	7%	13%	6%
c	9%	13%	25%	28%	3%	5%
d	4%	3%	4%	5%	4%	5%
e	4%	3%	8%	6%	56%	64%
f	4%	4%	1%	1%	4%	4%
g	3%	6%	3%	2%	1%	2%
h	1%	1%	1%	1%	0%	0%
i	0%	0%	0%	0%	0%	0%
j	0%	0%	1%	2%	9%	4%

(Table Continued)

Choice	16 Pre	16 Post	17 Pre	17 Post	18 Pre	18 Post
a	9%	9%	7%	4%	5%	7%
b	2%	4%	23%	23%	9%	5%
c	65%	65%	5%	8%	1%	4%
d	8%	5%	17%	17%	17%	23%
e	4%	3%	6%	4%	1%	4%
f	2%	4%	1%	4%	13%	6%
g	4%	4%	11%	11%	15%	15%
h	2%	4%	22%	20%	27%	27%
i	0%	0%	0%	0%	1%	0%
j	4%	1%	5%	8%	10%	9%

Choice	19 Pre	19 Post	20 Pre	20 Post	21 Pre	21 Post
a	4%	4%	2%	5%	8%	9%
b	6%	11%	4%	3%	14%	9%
c	11%	14%	6%	1%	8%	10%
d	16%	21%	4%	1%	10%	8%
e	4%	1%	4%	7%	7%	4%
f	6%	3%	65%	70%	8%	10%
g	24%	17%	3%	1%	9%	21%
h	15%	14%	8%	4%	13%	11%
i	0%	0%	0%	0%	0%	0%
j	13%	13%	5%	7%	20%	18%

Choice	22 Pre	22 Post	23 Pre	23 Post	24 Pre	24 Post
a	9%	12%	3%	7%	10%	12%
b	2%	3%	7%	6%	25%	30%
c	4%	5%	6%	2%	12%	9%
d	2%	2%	19%	13%	8%	5%
e	71%	70%	3%	4%	2%	7%
f	4%	4%	26%	30%	19%	11%
g	4%	3%	31%	35%	16%	21%
h	0%	0%	1%	0%	1%	0%
i	0%	0%	0%	0%	0%	0%
j	4%	1%	4%	4%	6%	4%

(Table Continued)

Choice	25 Pre	25 Post	26 Pre	26 Pre	27 Pre	27 Post
a	6%	11%	45%	41%	8%	10%
b	9%	7%	8%	8%	6%	12%
c	2%	5%	13%	15%	8%	8%
d	11%	11%	4%	6%	2%	5%
e	18%	15%	13%	18%	20%	15%
f	25%	27%	4%	1%	39%	27%
g	20%	17%	4%	4%	14%	20%
h	0%	0%	0%	0%	0%	0%
i	0%	0%	0%	0%	0%	0%
j	8%	7%	8%	7%	1%	2%

Choice	28 Pre	28 Post	29 Pre	29 Post	30 Pre	30 Post
a	3%	4%	13%	20%	46%	54%
b	6%	6%	47%	39%	7%	12%
c	6%	9%	15%	18%	9%	10%
d	62%	56%	7%	5%	11%	3%
e	8%	11%	4%	7%	19%	13%
f	9%	4%	7%	6%	4%	4%
g	4%	4%	3%	4%	0%	0%
h	0%	0%	1%	0%	0%	0%
i	0%	0%	0%	0%	0%	0%
j	1%	1%	3%	1%	3%	4%

Choice	31 Pre	31 Post	32 Pre	32 Post	33 Pre	33 Post
a	13%	17%	8%	10%	10%	11%
b	33%	32%	42%	36%	7%	6%
c	12%	13%	8%	13%	12%	5%
d	9%	12%	11%	6%	5%	6%
e	13%	11%	8%	11%	51%	58%
f	11%	8%	10%	11%	7%	4%
g	1%	1%	1%	0%	0%	0%
h	0%	1%	0%	0%	1%	0%
i	0%	0%	0%	0%	0%	0%
j	8%	5%	11%	13%	6%	8%

(Table Continued)

Choice	34 Pre	34 Post	35 Pre	35 Post	36 Pre	36 Post
a	11%	7%	30%	33%	11%	9%
b	43%	42%	41%	34%	14%	7%
c	7%	10%	13%	15%	44%	42%
d	8%	10%	6%	8%	14%	19%
e	9%	8%	3%	5%	6%	8%
f	8%	8%	1%	1%	1%	1%
g	1%	4%	1%	0%	0%	0%
h	0%	0%	0%	1%	2%	1%
i	0%	0%	0%	0%	0%	0%
j	11%	10%	4%	4%	8%	12%

Choice	37 Pre	37 Post	38 Pre	38 Post	39 Pre	39 Post
a	20%	20%	13%	13%	8%	11%
b	11%	17%	32%	32%	24%	13%
c	22%	28%	10%	17%	13%	17%
d	18%	14%	18%	9%	34%	34%
e	15%	8%	10%	10%	14%	16%
f	1%	1%	1%	2%	1%	1%
g	0%	1%	0%	1%	1%	0%
h	0%	0%	0%	0%	1%	1%
i	0%	0%	0%	0%	0%	0%
j	11%	9%	17%	15%	4%	4%

Choice	40 Pre	40 Post	41 Pre	41 Post	42 Pre	42 Post
a	32%	39%	8%	1%	6%	10%
b	6%	9%	11%	10%	30%	29%
c	7%	8%	13%	11%	22%	22%
d	29%	25%	5%	10%	12%	6%
e	15%	9%	2%	8%	8%	6%
f	2%	4%	19%	20%	4%	5%
g	1%	1%	23%	20%	3%	3%
h	4%	1%	13%	13%	10%	14%
i	0%	0%	0%	0%	0%	1%
j	3%	1%	6%	5%	4%	4%

(Table Continued)

Choice	43 Pre	43 Post	44 Pre	44 Post	45 Pre	45 Post
a	13%	11%	44%	50%	35%	37%
b	6%	8%	17%	13%	22%	18%
c	9%	5%	17%	25%	27%	27%
d	48%	44%	13%	6%	8%	8%
e	8%	8%	0%	1%	0%	1%
f	3%	2%	1%	1%	1%	0%
g	1%	1%	1%	1%	1%	1%
h	5%	10%	0%	0%	1%	0%
i	0%	0%	0%	0%	0%	0%
j	5%	8%	6%	4%	4%	7%

Choice	46 Pre	46 Post	47 Pre	47 Post
a	30%	29%	20%	25%
b	18%	18%	29%	25%
c	25%	24%	23%	18%
d	18%	18%	14%	14%
e	1%	1%	2%	1%
f	0%	0%	1%	1%
g	0%	0%	0%	1%
h	0%	1%	0%	0%
i	0%	0%	0%	0%
j	8%	8%	9%	14%

Appendix B Bell Ringer Questions

Student Name:____________________________Hour:_______ Day 1 Week 1

Which of these is an example of a force?

a. a car pushing a truck up a hill
b. a pitcher throwing a baseball
c. a gun shooting a bullet
d. all of the above

Student Name:____________________________Hour:_______ Day 2 Week 1

You toss a ball up into the air. As the ball is moving from your hand towards the highest point of the toss, which of these statements is true of the forces acting on the ball ?

a. the gravity > force of the ball is tossed up with
b. the force of gravity = the force that the ball is tossed up with
c. the force of gravity < the force the ball is tossed up with
d. the only force acting is gravity

Student Name:____________________________Hour:_______ Day 3 Week 1

You toss a ball up into the air. Which of these statements is true of the ball as it is falling back down through the air?

a. the main force acting on the ball is down and decreasing
b. the main force acting on the ball is down and constant
c. the main force acting on the ball is down and increasing
d. there is not enough information provided to answer this question

Student Name:___________________________Hour:_______ Day 4 Week 1

You are playing with a toy matchbox car. The floor is super smooth so there is very little friction. Which force would keep the car moving to the right at a steady (constant) rate?

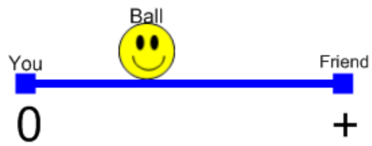
a. putting no force on the car
b. the force toward the right is decreasing in magnitude
c. the force toward the right is staying the same in magnitude
d. the force towards the right is increasing in magnitude

Student Name:___________________________Hour:_______ Day 5 Week 1

You are playing with a toy matchbox car. As you push it to the right friction is acting on the car. You maintain the same force as you push the car, but the car is slowing down due to a rougher surface. What can you say about the forces acting on the car as it moves to the right?

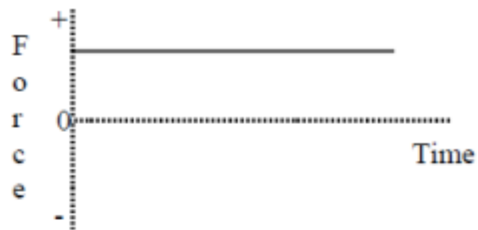
a. the force towards the left would increase and the force towards the right would increase
b. the force towards the left would increase and the force towards the right would decrease
c. the forces would be equal
d. the force towards the left would decrease and the force towards the right would decrease
e. the force towards the left would decrease and the force towards the right would increase

Student Name:_____________________________Hour:_______ Day 1 Week 2



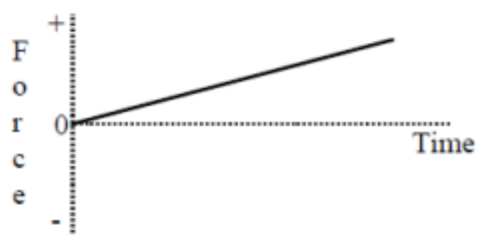
You are rolling a ball to a friend. Assuming that there is no friction, you roll the ball to the right and it is speeding up with a steady rate (Constant Acceleration). Which graph best represents this?

A



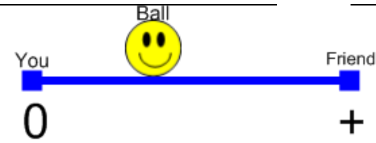
B

C



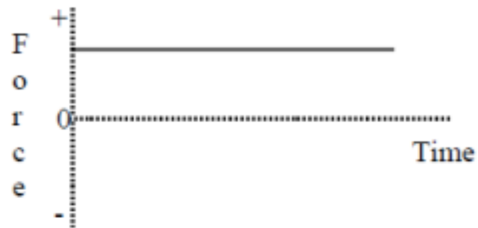
D

Student Name:______________________________Hour:________ Day 2 Week 2



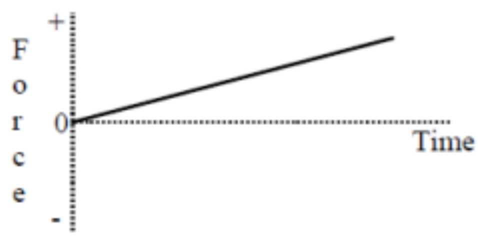
You are rolling a ball to a friend. Assuming that there is no friction, you roll the ball to the right and it is slowing down with a steady rate (Constant Acceleration). Which graph best represents this?

(A)



(B)

(C)



(D)

Student Name:____________________________Hour:_______ Day 3 Week 2

An 18-wheeler and a mini-cooper car are driving towards each other at 45 mph on a street. For reasons unknown to us they are heading straight for each other. Which choice describes the forces in the moment of the impact?

a. the force the truck exerts on the car is greater than the force the car exerts on the truck
b. the force the truck exerts on the car is less than the force the car exerts on the truck
c. neither exerts a force on the other the car is smashed because it is in the trucks way
d. the truck and car both exert the same force on each other

Student Name:____________________________Hour:_______ Day 4 Week 2

An astronaut is working on the Hubble Space Telescope when she drops her screwdriver. Since she is in space what is most likely to happen to the screwdriver?

a. it will continue to move in a straight line
b. it will go straight until the force of being dropped is used up
c. it will fall straight down towards earth
d. it will float in place until she picks it up

Student Name:____________________________Hour:_______ Day 5 Week 2

You toss a ball up into the air. As the ball is at highest point of the toss, which of these statements is true of the forces acting on the ball ?

a. the gravity > force of the ball is tossed up with
b. the force of gravity = the force that the ball is tossed up with
c. the force of gravity < the force the ball is tossed up with
d. the air is holding it in place

Appendix C IRB Exemption Documentation

Application for Exemption from Institutional Oversight

LSU

Institutional Review Board
Dr. Robert Mathews, Chair
131 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.6792
irb@lsu.edu
lsu.edu/irb

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/ projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

-- Applicant,Please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://www.lsu.edu/screeningmembers.shtml

-- A Complete Application Includes All of the Following:
(A) Two copies of this completed form and two copies of part B thru E.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.
*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information.)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (http://phrp.nihtaining.com/users/login.php.)
(F) IRB Security of Data Agreement: (http://www.lsu.edu/irb/IRB%20Security%20of%20Data.pdf)

1) Principal Investigator: Juana Moreno **Rank:** Asst Prof

Dept: LSU CCT **Ph:** **E-mail:** moreno@lsu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each

John Underwood
LAMSTI Graduate Student
337-351-9655
john.underwood@lpsb.org

IRB# E5587 LSU Proposal # ______
☑ Complete Application
☑ Human Subjects Training

3) Project Title: Do learning logs help with the conceptual mastery of motion in physical science?

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 12-8-2014

4) Proposal? (yes or no) NO **If Yes, LSU Proposal Number**

Also, if YES, either
○ **This application completely matches the scope of work in the grant**
OR
○ **More IRB Applications will be filed later**

5) Subject pool (e.g. Psychology students) 9th grade physical science students

*Circle any **"vulnerable populations" to be used**: (children <18; the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature Juana Moreno **Date** 08/07/11 (no per signatures)

**** I certify my responses are accurate and complete.** If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted √ Not Exempted ____ Category/Paragraph 1

Reviewer Mathews **Signature** Robt C Mathews **Date** 12/9/11

Vita

John Underwood was born to Jack and Gail Underwood in November of 1980 in Rome, Georgia. He attended elementary, middle, and high school in the Gordon County School District in Calhoun, Georgia. Upon his graduation in 1999 John attended Boston University in Boston, Massachusetts. John graduated in 2003 and joined Teach For America's South Louisiana Corps. After completing the New Teacher Project he became a highly qualified Biology, AP Biology, Environmental Science, Earth Science, Life Science, Physical Science, Forensic Science, Emergency First Responder, Medical Terminology, and 9-12 Social Studies teacher in Louisiana. He is a licensed American Heart Association Basic Cardiac Life Support for Health Care Providers Instructor and Emergency First Responder Instructor. He is currently entering into his tenth year of teaching and is a candidate for the Master of Natural Sciences Degree at Louisiana State University in Baton Rouge, Louisiana.