

THE EFFECTS OF INTRODUCTORY STATION LABS
IN HIGH SCHOOL PHYSICS

by

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July 2014

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ABSTRACT

The physics related experiences that students have are important for reflection when problem solving, building conceptual understanding and enriching their overall world view. This project used Introductory Station Labs to engage students in a variety of short collaborative investigations prior to the beginning of formal instruction for several units with three high school physics classes. The findings indicate that Introductory Station Labs are helpful by allowing students to make real-world connections, by providing sources of reflection while problem solving later in a unit and by enriching their experience with the world. A positive shift in student interest levels was noted. This study highlights the need to place more emphasis on reflection so that students can better develop the connections required to see the beauty of physics in the world around them.

INTRODUCTION AND BACKGROUND

I have been teaching physics and mathematics at St. Malachy's Memorial High School for the past 11 years. The school is located in Saint John, New Brunswick, Canada, near the city center. Saint John, the first incorporated city in British North America, has a population of 70,000, with a regional population close to 130,000 people. It is the largest city on the Bay of Fundy, and the median family income is \$68,520. A variety of post-secondary education is available through either the University of New Brunswick Saint John Campus or the New Brunswick Community College (City of Saint John, 2012).

St. Malachy's is home to just over 1,000 students as well as 65 teachers. St. Malachy's has a well-established set of traditions, as well as Advanced Placement (AP) programs for students studying biology, chemistry, physics, calculus, French, English, history, and art. A strong French immersion program exists. The school prides itself on maintaining a family atmosphere while supporting a thriving school spirit. Students in grades 11 and 12 are on a semester system, taking 5 courses per semester, and 10 courses per year. They are required to pass 17 of their 20 credits with a 60% (St. Malachy's Memorial High School, n.d.).

During my time at St. Malachy's I have noticed many students in my physics classes have not had the types of experiences one would expect a 16 or 17 year old to have. For example, when discussing inertia, I often refer to the experience of having to push a broken down car. Typically only a few students relate to this experience. Due to the relative inexperience with the physical world, making progress with conceptual understanding can be difficult. Eisenkraft (2013) speaks to this same issue in his most

recent article: “We mistakenly assume that all students have had these experiences, have made careful observations, and can substitute their memories and logic for experimental evidence” (p.43).

A few years ago I decided to make a sustained effort at ensuring students had several common experiences directly related to the unit of study before starting any formal instruction. I refer to these series of short experiments and inquiry activities as Introductory Station Labs. At the beginning of each unit the students work in groups, rotating around to different stations, trying out the suggested activities and attempting to answer the questions asked. They are asked to discuss their ideas with each other and to record their observations and thoughts. These common experiences equalize the playing field when questions and problems arise later in the unit. In the initial interviews I conducted with my students, one student said, “The station labs helped open your eyes to how what we are going to be learning is used in real life.” Another student said, “They gave a real world foundation and you can relate it to other questions or further research.” The Introductory Station Labs increase the level of engagement and collaboration while students answer questions or describe a particular phenomenon.

The lab papers the students hand in also become part of their portfolio. By the end of the unit, students have taken various opportunities to reflect on their initial comments and ideas regarding the stations in the introductory labs. After receiving initial written teacher feedback, students are encouraged to make additions to show how their conceptual understanding has improved. In some ways, the Introductory Station Labs act like a journal as the students record the ways their thoughts and understandings have changed.

This led to the creation of my focus statement: *What are the effects of implementing an Introductory Station Lab for each unit of study in a high school physics class?* In addition, the following sub-questions were researched:

- What are the effects of Introductory Station Labs on student performance and conceptual understanding?
- What are the effects of Introductory Station Labs on student interest in studying physics?
- What are the effects of Introductory Station Labs on how students later experience the physical world?

CONCEPTUAL FRAMEWORK

Physics teachers involve students in small collaborative group work, active learning environments, real-world problems, contextualized scaffolding, journals, and labs in an effort to maximize conceptual understanding, and problem solving ability. All are key strategies producing effective experiences for students (Adams et al., 2006; Hand, Hohenshell, & Prain, 2004; Haussler & Hoffmann, 2002). Experiences allow students the possibility of seeing the world in a different way (Enghag, Gustafsson & Jonsson, 2007). Dawkins (1998) describes how such experiences can enrich our worldview, saying, “They’ve actually made me feel that the world around me is a much fuller, much more wonderful, much more awesome place than I ever realized it was” (p.37). Classroom activities should allow students to see the world, as if through new eyes. When students leave high school classrooms better prepared to recognize the beauty of physics in their everyday experiences, then teachers have truly had an impact.

Students have been experimenting with physics most of their lives. They have thrown balls, dropped eggs, floated boats, and driven in cars. These types of activities have given students a certain amount of common sense knowledge about the world around them (Sherin, 2006). Phillips and Barrow (2006) concluded it is difficult to separate extra experiences in physics from an increase in conceptual understanding. A student's ability to tinker, or be playful, while scrutinizing their world helps develop scientific thinking skills (Parsons, 1995; Hasse, 2008). Hasse (2008) also mentions teachers are more likely to recognize and encourage these playful students. It is through mindful playfulness that new questions and investigations materialize (Hazari et al., 2010). When teachers encourage playfulness along with discussion about underlying principles, student interest and positive attitudes towards physics can be increased (Ponderso, 2013).

Osborne (2003) found when students discuss their experiences with the physical world, they are motivated to learn more. Students are likely to feel a sense of belonging and interest, and they will continue to contribute their ideas to the class (Enghag, Gustafsson & Jonsson, 2007; Maltese & Tai, 2010). Positive experiences are also associated with an increase in cognitive activity, and expectancy of success (Buff et al., 2010). Competency, performance and recognition were identified as critical factors for developing science identity (Hazari et al., 2010).

Small group work during inquiry-based, relevant, open-ended, investigative labs and hands-on activities, is essential for all science courses (Shaw, 2005). When exploration of ideas is combined with group discussion, students can interpret the ideas of others and mold many ideas to develop new understandings (Enghag, 2007). Inquiry-

based labs that adopt a guided construction approach while involving peer interaction can produce larger gains in students' conceptual understanding (Bernhard, 2010; Cooper, 2002). When these design activities are correctly embedded in content and scaffolded with formative, continuous feedback, scientific minds are nascent (Etkina, Karelina & Ruibal-Villasenor, 2013).

Increases in student motivation and conceptual understanding occur when students engage in these types of activities. Rukavina (2012) reports on students positive experiences during workshops that encouraged active engagement. The results indicate students were eager to learn in a workshop format, and they valued the applications and hands-on experimentation. Mestre (1994) also identified considerable conceptual gains when students were given time to construct explanations and reflect (Cooper, 2002; Crouch, et al., 2007; Hake, 2012; Koschmann et al., 1994). These shared experiences eliminate the need for students to rely solely on prior experience with the physical world (Ciske, 2002; Milne, 2007). Interest and excitement are generated in the short-term, while important memories are created that can be referred to later in the unit (Milne, 2007; Shaw, 2005). Students who have been exposed to all of these types of activities during class time will have plenty of experiences upon which to reflect.

Allowing students the opportunities to write about their experiences with the physical world and to later reflect on this writing is beneficial. Barron (2007) identifies journal writing as a way for students to internalize science information, while allowing teachers to check their students' understanding. Journals may also be a way of dealing with misconceptions in physics (Joyner and Larkin, 2002). Reflective writing helps

students to move from a common-sense understanding of the world to a Newtonian understanding of how the world works (Doherty, 2010).

When students have common experiences, questions that involve these common experiences can be tested, refined, and integrated into their current framework (Leonard et al., 1999; Sherin, 2006). Enghag, Gustafsson and Jonsson (2007) have found students were better prepared for physics reasoning after discussing their own everyday experiences related to the task. Sharing and reflection are very valuable to future quantitative problem solving (Heller & Hollabaugh, 1992). Proficient problem solvers are able to understand a physics problem in a conceptual sense, and analyze it qualitatively (Leonard et al. et al., 1999). Other researchers have noted this focus on conceptual understanding for problem solving is particularly important for females who generally have fewer extra-curricular physics-based experiences to draw upon (Hazari et al., 2010). Additionally Hazari et al. (2006) have related a focus on conceptual understanding to performance and interest (Otero & Gray, 2008).

Giving students various types of experiences, combined with the time to discuss and reflect, will generate students who are better prepared to reason, analyze and solve problems. Pugh (2004) suggests educators focus on using experiences in a high school physics class to enrich the lives of our students.

METHODOLOGY

This study involved implementing Introductory Station Labs for several units in a high school physics classroom to determine the effects on student performance, engagement, experience and conceptual understanding. Three 12th grade physics classes completed Introductory Station Labs for vectors, dynamics, torque, circular motion, and

energy. 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 (Appendix A).

Students worked in small groups through a series of short investigative labs and hands-on activities directly related to the unit of study which they were about to begin. This exploration occurred before any formal instruction on the topic had taken place. At each station, students were expected to ask a question, make a diagram, describe their observations, or to complete a small table of data based on the activity at that station. They also discussed their experiences with their group members, shared ideas and wrote a possible explanation to a question posed at each station (Figure 1).



Figure 1. A group of students working at a station involving a stringless pendulum.

Each station lab accompanied by student's thoughts, diagrams and initial explanations marked the beginning of a unit of study. Upon completion, I reviewed each lab, provided as much formative feedback as necessary, and added questions where appropriate. No summative grade was assigned. As the unit progressed, students were encouraged to reflect upon what they had written, deal with any misconceptions, and refine their thoughts or make additions where required. To receive full summative credit for completing the introductory station lab, all of these steps must have taken place.

A variety of quantitative and qualitative data was collected to determine the effects of introductory station labs (Table 1). All students completed the Force Concept Inventory (Hestenes, Wells & Swackhamer, 1992) as well as the Mechanics Baseline Test (Hestenes & Wells, 1992) pre-treatment to create a baseline of student conceptual understanding in the area of Newtonian mechanics. Each of these instruments consisted of a series of multiple choice questions probing at possible misconceptions students may have in the areas of energy conservation, motion, forces and work. These misconceptions were grouped, and the percentage of each class choosing a dominant incorrect answer was calculated. An incorrect answer was considered as being dominant if it represented more than 25% of the answers (Appendix A). The Force Concept Inventory and Mechanics Baseline Test were also completed post-treatment. Analysis was performed on the post-treatment data to determine gain in conceptual understanding for the seven focus areas. Gain was calculated using the formula $G = (\text{post-pre}) / (100 - \text{pre})$.

A modified version of the Colorado Learning Attitudes about Science Survey (CLASS) was also administered to all students before treatment began (Appendix B). The modified CLASS required students to respond to questions regarding their beliefs

about physics and learning physics using a Likert-style five point scale with 1 being strongly disagree and 5 being strongly agree. A post-treatment modified CLASS survey was also given and analysis was performed on any shifts in student attitude towards physics. Categories of analysis for this survey included personal interest, real-world connection, problem solving, sense making effort, conceptual understanding, and expert perspective.

Once the treatment began, observations of students during the Introductory Station Labs were made using the Introductory Station Lab Monitoring Chart to record levels of student engagement (Appendix C). Records of student responses on each Introductory Station Lab were also kept. These qualitative responses and comments were used as evidence for the baseline of conceptual understanding related directly to the unit of study. Completed lab notebooks which included updated Introductory Station Labs for each unit were compared with records taken immediately following each introductory station lab in an effort to gauge changes in students' conceptual understanding. The Introductory Station Lab Monitoring Charts were also updated post-lab and comparisons were made.

All students were required to complete a midterm and final examinations. Student responses from these tests were used as qualitative evidence of conceptual understanding. How students experienced the physical world and were able to explain their understanding was compared to baseline data taken from the initial Introductory Station Lab responses.

The Wells Station Lab Interview was conducted with each student about midway through the semester to inquire how Introductory Station Labs had impacted their

conceptual understanding, as well as their interest in studying physics (Appendix D).

The Wells Post-Treatment Interview was conducted with each student post-treatment in an attempt to determine the effects of Introductory Station Labs on student experiences with the physical world (Appendix E).

There were three primary questions regarding Introductory Station labs and their effects on conceptual understanding, engagement and experience with the physical world (Table 1). The FCI and MBT along with student lab notebooks were used to analyze the effects of Introductory Station Labs on student conceptual understanding. The CLASS, teacher observations, the Introductory Station Lab Monitoring Chart and the Wells Station Lab Interview were used to determine the effects on student engagement and interest. The Wells Station Lab Interview and Post-treatment Interview along with questions from the midterm and exam were used to analyze the effects of Introductory Station Labs on student experience with the physical world.

Table 1
Data Triangulation Matrix

Research Questions	1	2	3
What are the effects of introductory station labs on student conceptual understanding?	Force Concept Inventory and pre and post treatment	Student lab notebooks	Midterm and final exam
What are the effects of introductory station labs on student engagement and interest?	Attitudes about Science Survey pre and post treatment	Introductory Station Lab Monitoring Chart	Wells Station Lab Interview
What are the effects of introductory station labs on student experience with the physical world?	Teacher-made midterm and final exam	Wells Station Lab Interview	Wells Post-treatment Interview

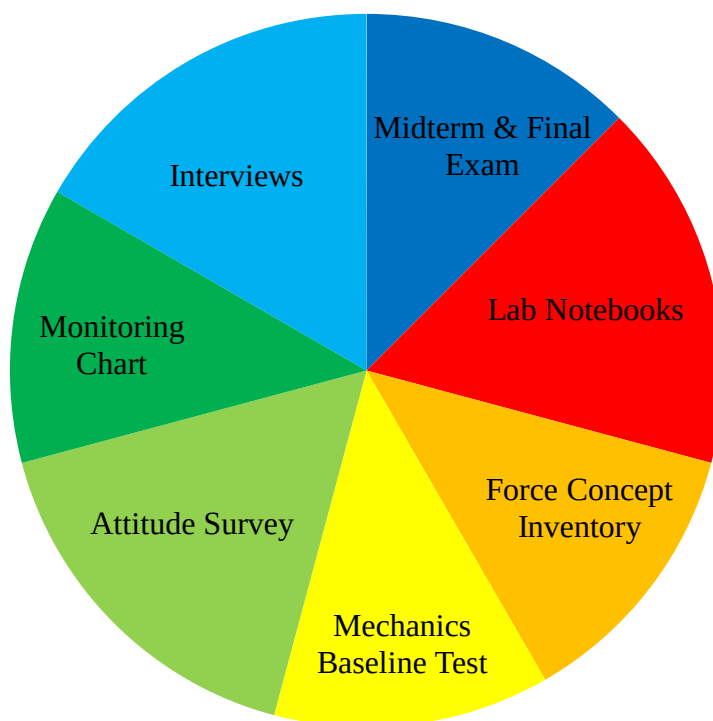


Figure 2. Instruments used for data and analysis.

DATA AND ANALYSIS

The results of the Modified Colorado Learning Attitudes towards Science Survey (CLASS) given pre-treatment indicates that 63% of the AP Physics class considered conceptual understanding of physics concepts to be important while 43% of Physics 122 students agreed ($N=46$). The highest number of AP Physics students chose *agree*, while the highest number of Physics 122 students in each class chose *neutral* to statements like *After I study a topic in physics and feel that I understand it, I do not have much difficulty solving problems on the same topic* (Figure 3).

The results of the pre-treatment Force Concept Inventory reveal that the AP Physics class scored an average of 56.3%, while the Physics 122 classes scored an

average of 37.9%. A comparison of the classes is shown in Figure 4, which consists of a histogram with the number of correct answers out of a possible 30 questions.

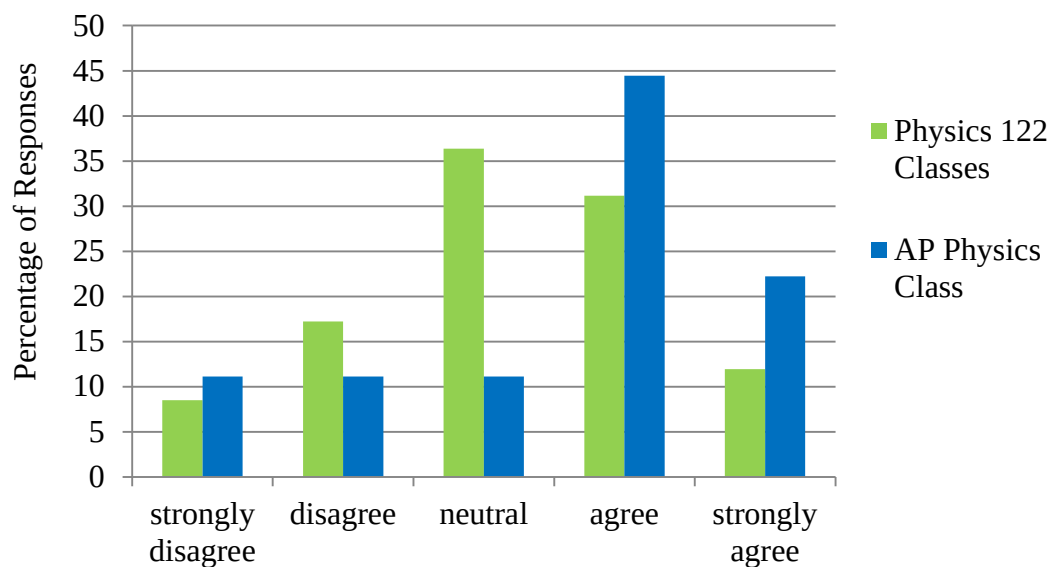


Figure 3. Student responses related to conceptual understanding, ($N=46$).

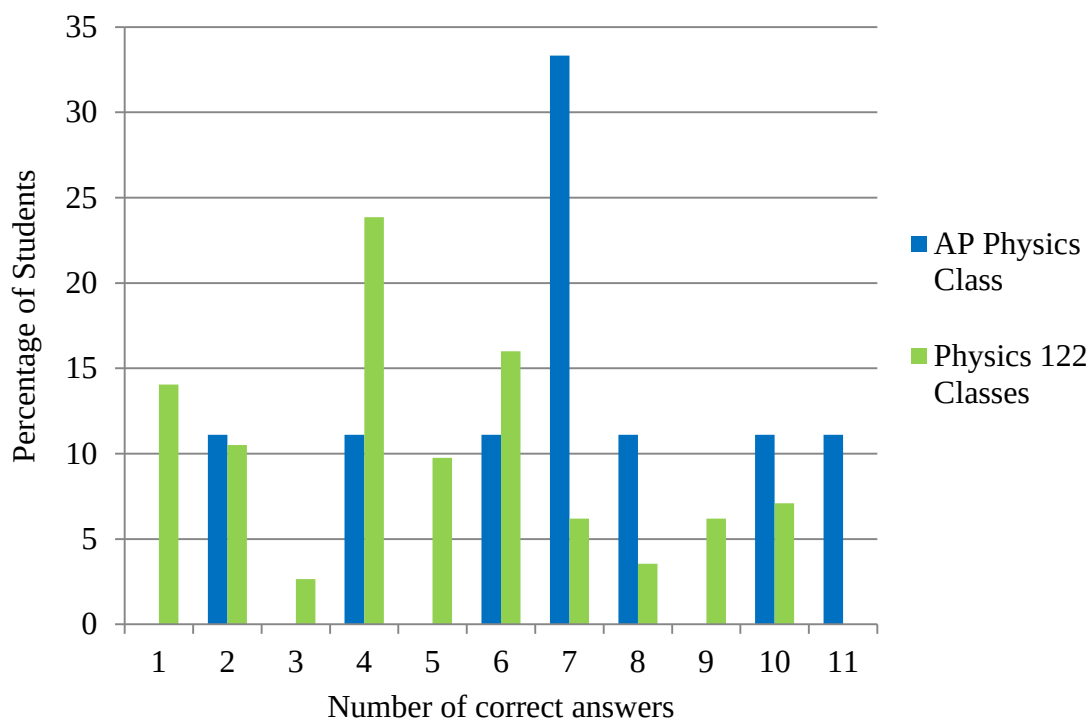


Figure 4. Pre-treatment results of the Force Concept Inventory, ($N=46$).

An analysis of student misconceptions using the Force Concept Inventory pre-treatment shows that the AP Physics class and the Physics 122 classes differ in terms of the percentage of students choosing dominant incorrect answers (Figure 5). While the percentage of students in each class choosing dominant incorrect answers varies greatly, 75% of the students in each class shared the same misconceptions.

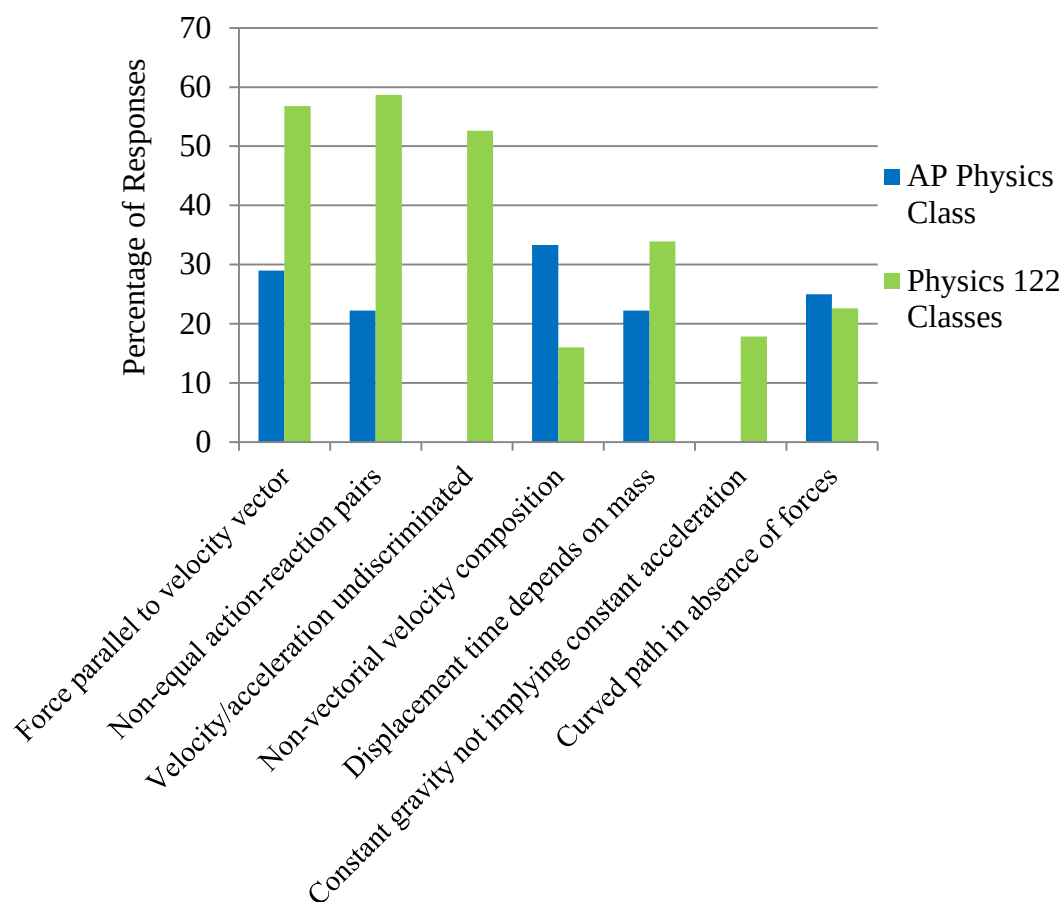


Figure 5. Student misconceptions with a dominant incorrect answer on the Force Concept Inventory, ($N=46$).

Similarities in the types of misconceptions and the percentages of students holding these misconceptions can also be seen in Figure 6. Shown below is a correlation plot of the normalized dominant incorrect answers given by the AP Physics class versus the average of the Physics 122 classes for the seven different categories of misconceptions. A correlation can be noted between the percentages of dominant incorrect answers given by each group of students for the categories.

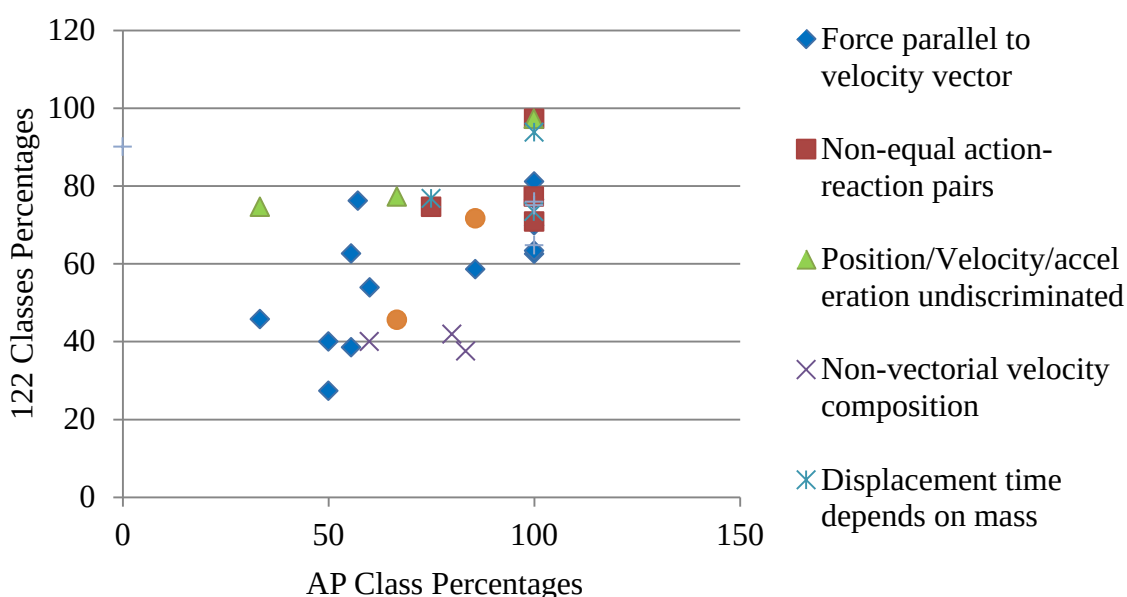


Figure 6. Correlation plot of the normalized dominant incorrect answers, ($N=46$).

Class performance varied again on the pre-treatment Mechanics Baseline Test, with the AP Physics class scoring an average of 38% and the Physics 122 classes scoring an average of 22%.

The results of the post-treatment Force Concept Inventory, and the post-treatment Mechanics Baseline Test indicate that all three classes made gains in their conceptual understanding Newtonian Mechanics. The percentage of students selecting a dominant

incorrect answer on the Force Concept Inventory given post-treatment decreased in six of the seven categories in both classes (Figure 7).

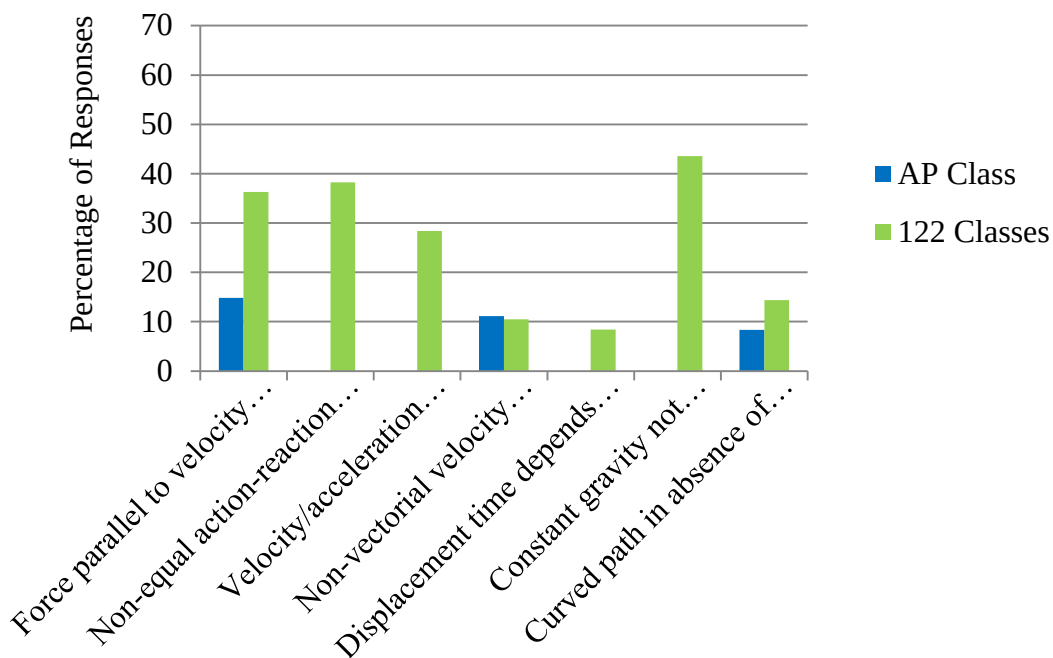


Figure 7. Student misconception with a dominant incorrect answer on the Force Concept Inventory given post-treatment, ($N=46$).

The results from student lab notebook feedback regarding conceptual understanding indicated that 88% of AP Physics students were able to achieve a *G* (Green) on their station labs, while 72.5% of Physics 122 students were able to do the same (Figure 8). One student said, “Working on the station labs gives you a general introduction to the concepts involved in the topic that you are going to work on. I’m a visual and hands-on learner, so I find that the station labs really help. I didn’t complete the torque station lab and then I ended up failing the test, so I think that really shows the benefit of the station labs. I find they are really, helpful, and they are kind of cool.”

Similar evidence was collected from student midterms and exams. On short answer questions that required students to respond and give an explanation, 78% of AP Physics students and 58 % of Physics 122 students achieved full credit.

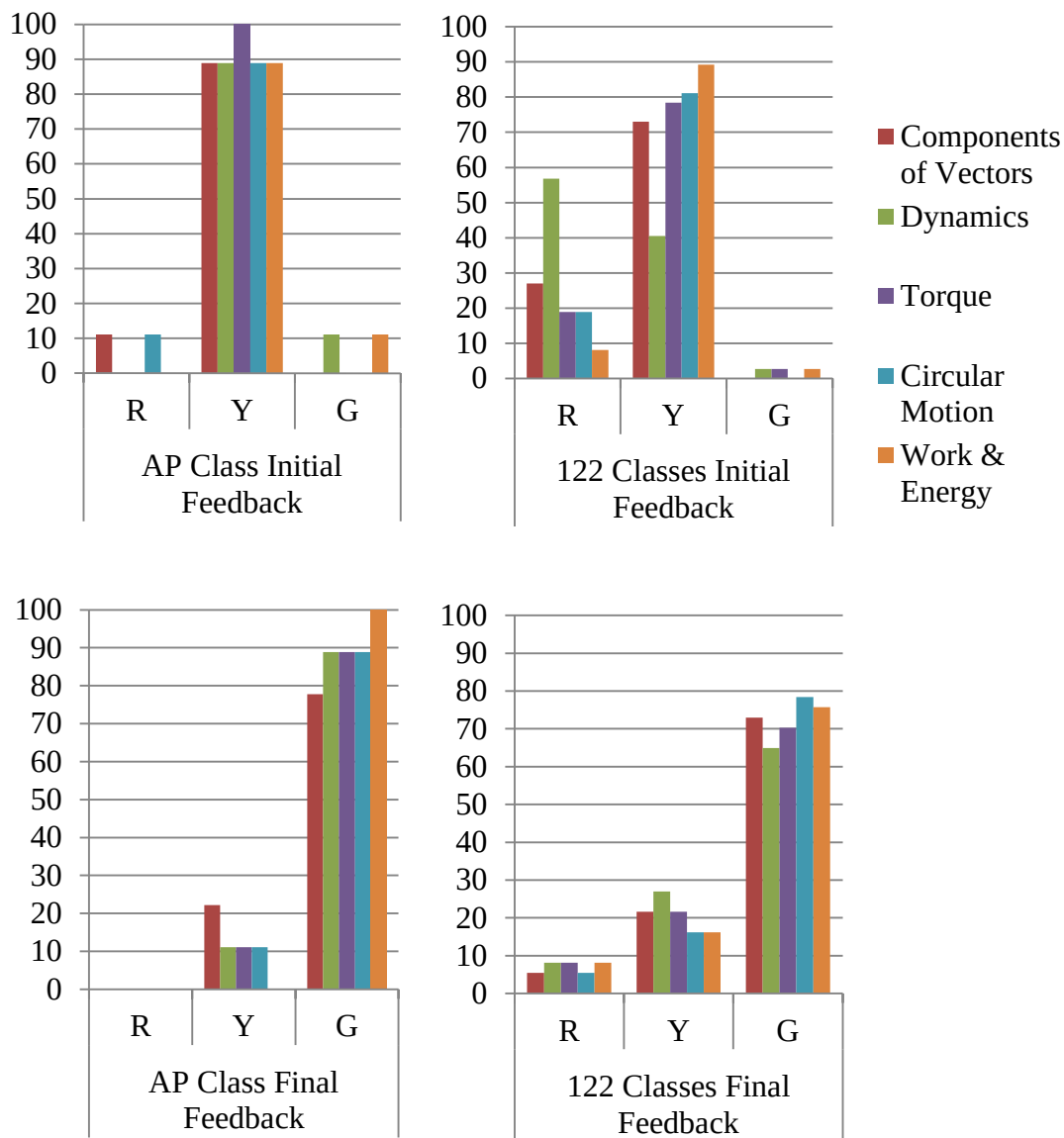


Figure 8. Percentage of students receiving R (Red), Y (Yellow) or G (Green) feedback on their lab notebooks for each station lab, ($N=46$).

The results of the Modified Colorado Learning Attitudes towards Science Survey (CLASS) given pre-treatment indicate that 52% of the respondents had a personal interest in physics ($N=46$). While 71% of the AP Physics class said that they enjoy solving physics problems, only 43% of the students in the Physics 122 classes agreed (Figure 9).

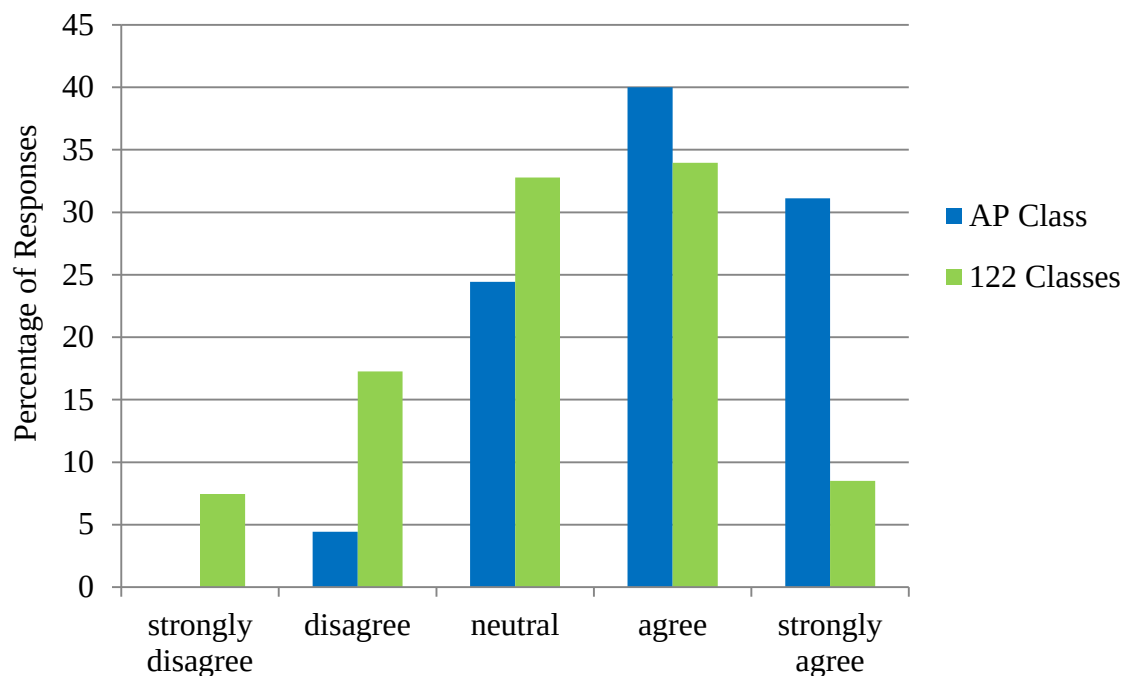


Figure 9. Student interest in physics pre-treatment, ($N=46$).

Regarding questions related to the real world connections of physics, 70% of the AP Physics class responded favorably. Agreeable responses were given by 41% of the Physics 122 Classes. One question in this group was, *Reasoning skills used to understand physics can be helpful to me in my everyday life* (Figure10). The average number of Physics 122 students who responded unfavorably to these types of questions was 23% higher than the AP Physics class.

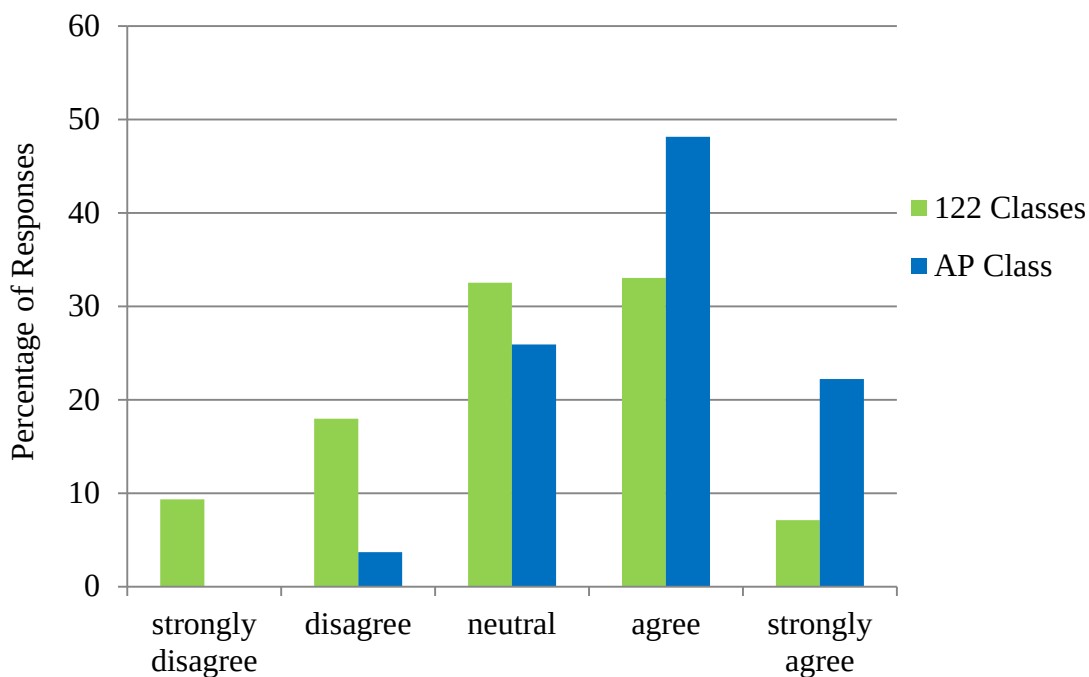


Figure 10. Student perception of the real world connection of physics pre-treatment, (N=46).

Analysis of the post-treatment modified CLASS shows a positive shift for student interest in physics, as well as in student perception of the real world connection of physics (Figure 11). One student said, “The labs helped open your eyes to how what we are going to be learning is used in real life.” Another student said, “They kind of got you thinking, not just about the concepts but watching it work.” All students also commented positively on how the labs affected their learning. “They gave a real world foundation.” “You can relate it to other questions or further research.”

The results from the introductory station lab monitoring charts indicate that all students in each class were able to *make observations, record observations, record questions, share ideas with group members, and interact positively with peers* during the Introductory Station Labs. While 88% of AP Physics students made *constructive*

contributions to the group during the station labs, 73% of Physics 122 students were able to do the same.

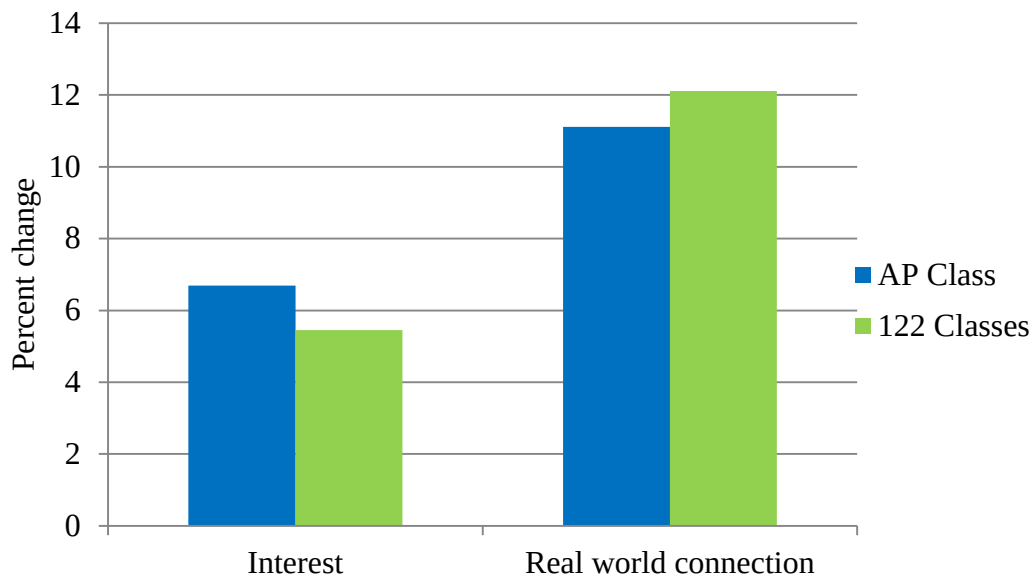


Figure 11. Positive shift in student attitudes pre-treatment to post-treatment, ($N=46$).

The results of the Wells Station Lab Interview indicate that 100% of AP Physics students and 62.7% of Physics 122 students said that the Introductory Station Labs helped to increase their interest in physics (Figure 12).

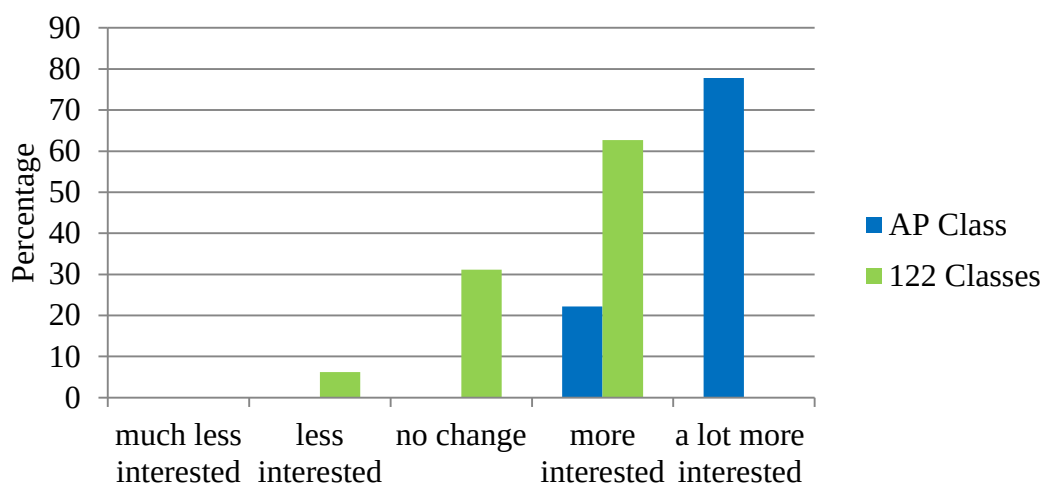


Figure 12. Percentage of students rating their interest level change in physics due to the Introductory Station Labs, ($N=46$).

When responding to whether the Introductory Station Labs helped to be helpful, 100% of students agreed. One student said, “I am more inquisitive about everyday occurrences, and I constantly relate the topics learned in class to life outside of school.” Other students said, “They increased my knowledge about everyday events and it increased my questioning of how something is working,” and “You got to watch and physically see what was actually happening instead of just reading about it and not being able to picture it in your mind.” Several students responded by saying how the station labs helped them to “understand the theory and make it easier to remember,” or “visualize how the forces act in certain situations.”

When responding to *Did you discuss a station lab with someone outside of class?*, 67% of AP Physics students and 36% of Physics 122 students said yes (Figure 13). One student said, “I tell people all the time. I tried to get my math class to do the chair lifting thing from the torque station lab. For ninety-five percent of the labs we do, I leave class and talk about them.” Other students said, “My gymnastics coach is constantly using the term center of mass, so I talked to him about a few different stations from the station lab,” and “I thought about torque when we were working on the sets for the musical. We had a ladder set up, and the flats for the set were quite tippy.”

One hundred percent of AP Physics students related something they learned from an Introductory Station Lab to something they experienced outside of class at least four times by midterm. An average of 33% of Physics 122 students related an experience four to six times (Figure 14). One student said, “I have to work construction with my dad sometimes, lifting boards and stuff, so it made me think about torque.” Other students said, “The components of vectors lab is one that I think about whenever I’m aiming. I

think about that whenever I golf.” “After we looked at the spinning wheel I related that to when you are in the air for motocross and you stop your back wheel how the front of the bike will drop, and if you gas how the front of the bike will lift.”

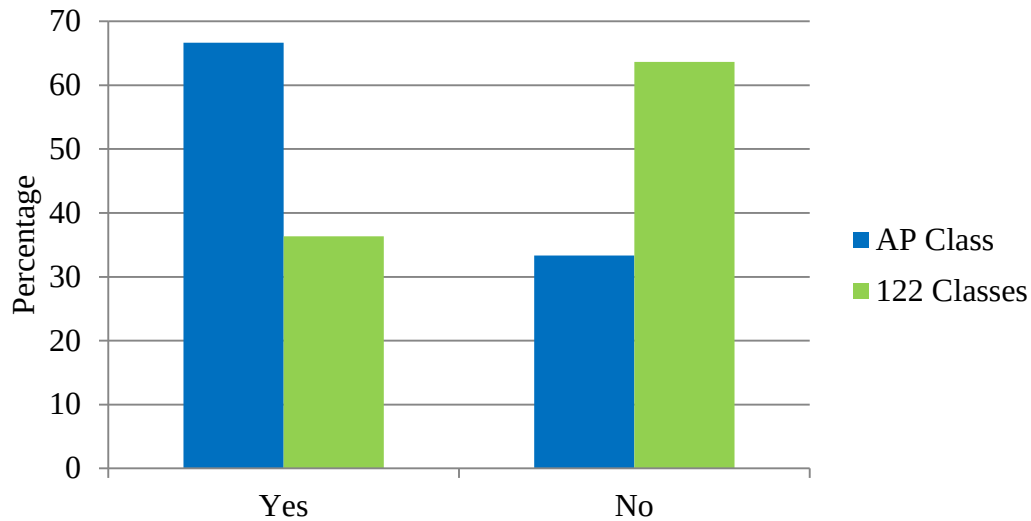


Figure 13. Percentage of students discussing a station lab with someone outside of class, (N=46).

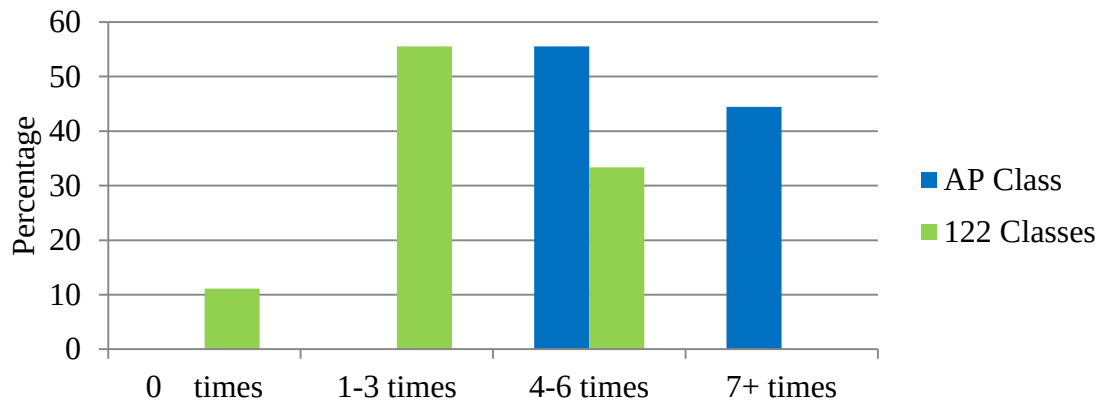


Figure 14. Number of times students related something from an Introductory Station Lab to something experienced outside of class, (N=46).

The results of the Wells Post-treatment Interview give a more complete picture of the particular unit where these relations are taking place most frequently (Figure 15). AP Physics students reported relating an experience outside of class 5+ times 89% of the

time. The Physics 122 students related an experience 3 or more times for 33% of the Introductory Station Labs. In relation the unit on circular motion, one student said, “When I’m driving a car on a hill, now I know why I feel pushed down at the bottom and lighter at the top. I think about the normal force, same as on a roller coaster.” Another student said, “I find it hard to do anything, sports especially, without wondering how it could relate to physics in some way. When I think of hockey I think of collisions and forces. When I think of golf I think of collisions and projectiles.”

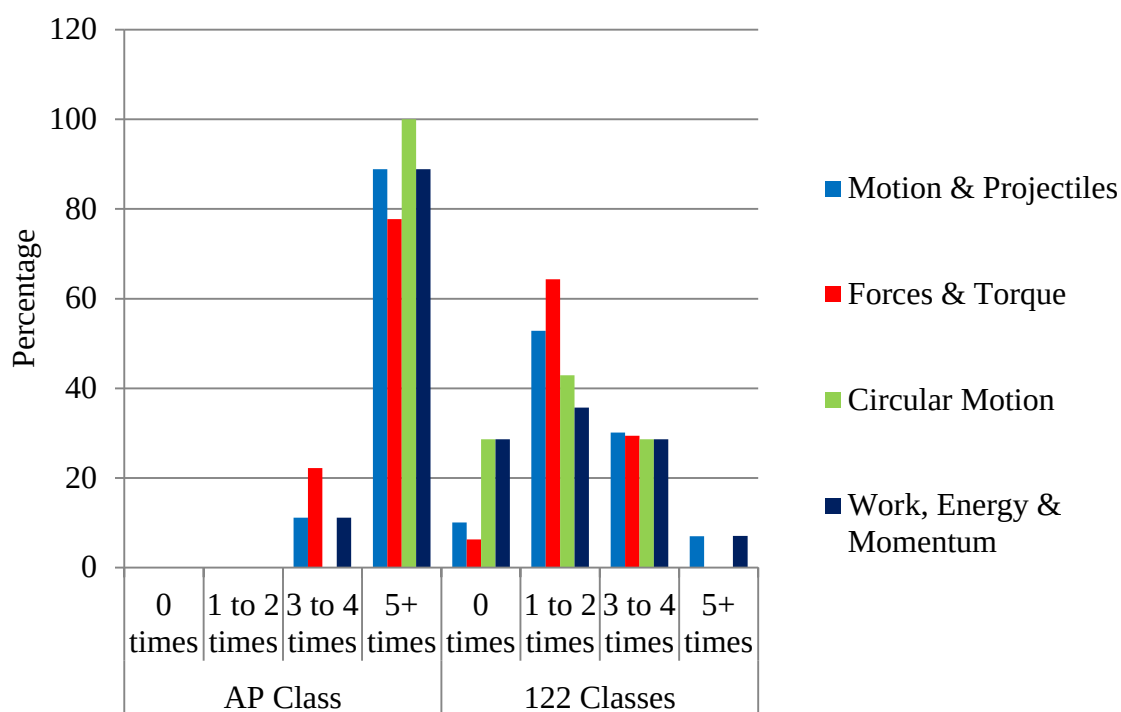


Figure 15. Percentage of students relating an Introductory Station Lab to an experience outside of class, (N=46).

During the Wells Post-treatment Interview many students commented on how their understanding of physics has impacted their experience with the world around them. One student said, “Actually, after I’ve done a unit, everything looks like physics. It goes on all around me and it’s fun actually. Like when I’m throwing a ball, I think about

physics now.” Other students said, “The knowledge has opened my eyes to the world as a whole and its logical functioning” and “Understanding physics makes me realize that there is more going on than we think.”

INTERPRETATION & CONCLUSION

The implementation of Introductory Station Labs has had positive influences on all three focus areas including conceptual understanding, engagement & interest, and experience with the physical world. The results from the post-treatment Force Concept Inventory and Mechanics Baseline Test show considerable gains in student conceptual understanding. While larger gains were noted for the AP Physics class over the Physics 122 class, both groups of students were able to effectively demonstrate their understanding of Newtonian mechanics principles through explanations given in their lab notebooks, midterm and final examinations. It should be noted that although gains were made, many of the seven misconceptions studied remained evident in the post-treatment results.

The students reported that their interest level in physics increased due to the Introductory Station labs through both the CLASS survey as well as during the interviews. The increase in interest was greater for the AP Physics class than the Physics 122 class. A few Physics 122 students reported their interest levels decreasing. This may be due to the negative attitudes that a small number of students developed over the course of the term as they were unsuccessful in learning the course material.

All evidence collected shows that changes to how students experience their world were more likely for those students who were able to spend more time reflecting on their learning. The AP Physics class reported reflecting on their classroom experiences to a

greater extent than the Physics 122 classes. They were also much more likely to later relate an experience outside of class to something from an Introductory Station Lab. This may be due to the increased reflection time on the labs themselves. While some changes were noted in the experience of the Physics 122 class, students seemed to connect to one unit more than others. During the Wells Post-treatment Interview, Physics 122 students who commented on how their experience with the world had changed focused on one unit and gave examples. The AP Physics students described more of a shift in their overall world-view.

VALUE

The very first thing I think of when reflecting on this project in my classroom is the students. I am always looking for practical ways to improve their performance in the most interactive way possible. Giving students' feedback throughout the process has been the key to an ever-evolving rapport, good communication, mutual understanding and respect. Through data collection, feedback, and reflection taken on during this project I have gained new insights into my teaching. I am able to make good decisions concerning the way students in my classroom can best reach the prescribed outcomes. I believe that this study highlighted the emphasis that I need to place on reflection in the classroom. The more time students spend reflecting on physics concepts and how they connect to their everyday experiences, the better they perform on assessment.

My primary professional goals have been to move the results of science education research into the classroom, to create a balance between quantitative problem solving and conceptual understanding, to continue fostering an active learning environment, and to improve student learning and assessment. When starting to teach any physics class I like

to picture each student walking out of the final exam. In what ways will they be different from the students sitting in front of me? Will they have some of the passion that I do, for further understanding how the world works? Will they be able to see the physics in everyday life? This project has helped me to see that I am making a difference and working toward meeting these goals.

Using the multiple assessment methods with my classes, then spending time analyzing the results has truly revitalized my teaching. It was both interesting and rewarding to look at the data collected. Students in all three classes made positive gains in all three of the focus areas; conceptual understanding, interest and experience with the physical world. Taking this systematic approach with my students has helped to shape my professional development. I am encouraged and believe that having worked through an entire project has been very rewarding on a professional level, as well as on a personal level. Conducting research using my classes has also allowed my students to see me as a continuous learner. I hope that this will encourage them to become life-long learners as well.

Teaching physics is what I love to do best. I try to ensure that all my students come to recognize that they *can* understand physics and that it is valuable to them. I envision them living a more meaningful life because of the understanding they have gained into the bigger picture of how the world works. I consider it my job to convey the wonder, the beauty, and the elegance of the way the laws of physics align themselves with the physical world.

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APPENDICES

APPENDIX A
IRB EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Jocelyn Wells and John Graves
FROM: Mark Quinn, Chair *Mark Quinn*
DATE: May 17, 2013
RE: "The Effects of Introductory Station Labs in High School Physics" [JW051713-EX]

The above research, described in your submission of May 17, 2013, 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 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

FORCE CONCEPT INVENTORY STUDENT RESPONSE SHEET

FORCE CONCEPT INVENTORY STUDENT RESPONSE SHEET

Question	Answer	I am confident that my answer is correct.	Write number here
1		Strongly Disagree 1 2 3 4 5 Strongly Agree	
2		Strongly Disagree 1 2 3 4 5 Strongly Agree	
3		Strongly Disagree 1 2 3 4 5 Strongly Agree	
4		Strongly Disagree 1 2 3 4 5 Strongly Agree	
5		Strongly Disagree 1 2 3 4 5 Strongly Agree	
6		Strongly Disagree 1 2 3 4 5 Strongly Agree	
7		Strongly Disagree 1 2 3 4 5 Strongly Agree	
8		Strongly Disagree 1 2 3 4 5 Strongly Agree	
9		Strongly Disagree 1 2 3 4 5 Strongly Agree	
10		Strongly Disagree 1 2 3 4 5 Strongly Agree	
11		Strongly Disagree 1 2 3 4 5 Strongly Agree	
12		Strongly Disagree 1 2 3 4 5 Strongly Agree	
13		Strongly Disagree 1 2 3 4 5 Strongly Agree	
14		Strongly Disagree 1 2 3 4 5 Strongly Agree	
15		Strongly Disagree 1 2 3 4 5 Strongly Agree	
16		Strongly Disagree 1 2 3 4 5 Strongly Agree	
17		Strongly Disagree 1 2 3 4 5 Strongly Agree	
18		Strongly Disagree 1 2 3 4 5 Strongly Agree	
19		Strongly Disagree 1 2 3 4 5 Strongly Agree	

20		Strongly Disagree	1	2	3	4	5	Strongly Agree	
21		Strongly Disagree	1	2	3	4	5	Strongly Agree	
22		Strongly Disagree	1	2	3	4	5	Strongly Agree	
23		Strongly Disagree	1	2	3	4	5	Strongly Agree	
24		Strongly Disagree	1	2	3	4	5	Strongly Agree	
25		Strongly Disagree	1	2	3	4	5	Strongly Agree	
26		Strongly Disagree	1	2	3	4	5	Strongly Agree	
27		Strongly Disagree	1	2	3	4	5	Strongly Agree	
28		Strongly Disagree	1	2	3	4	5	Strongly Agree	
29		Strongly Disagree	1	2	3	4	5	Strongly Agree	
30		Strongly Disagree	1	2	3	4	5	Strongly Agree	

APPENDIX C

MODIFIED CLASS (COLORADO LEARNING ATTITUDES ABOUT SCIENCE
SURVEY)

CLASS (COLORADO LEARNING ATTITUDES ABOUT SCIENCE SURVEY)

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Here are a number of statements that may not describe your beliefs about learning physics. You are asked to rate each statement by circling a number between 1 and 5 where the numbers mean the following:

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Choose one of the above five choices that best expresses your feeling about the statement. If you don't understand a statement, leave it blank. If you understand, but have no strong opinion, choose 3.

Survey

1. A significant problem in learning physics is being able to memorize all the information. I need to know.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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2. When I am solving a physics problem, I try to decide what would be a reasonable value for the answer.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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3. I think about the physics I experience in everyday life.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

4. It is useful for me to do lots and lots of problems when learning physics.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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5. After I study a topic in physics and feel that I understand it, I have difficulty solving problems on the same topic.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

6. Knowledge in physics consists of many disconnected topics.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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7. There is usually only one correct approach to solving a physics problem.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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8. I am not satisfied until I understand why something works the way it does.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

9. If I get stuck on a physics problem my first try, I usually try to figure out a different way that works.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

10. Nearly everyone is capable of understanding physics if they work at it.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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11. Understanding physics basically means being able to recall something you've read or been shown.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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12. To understand physics I discuss it with friends and other students.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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13. I do not spend more than five minutes stuck on a physics problem before giving up or seeking help from someone else.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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14. In physics, it is important for me to make sense out of formulas before I can use them correctly.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

15. I enjoy solving physics problems.

Strongly Disagree	1	2	3	4	5	Strongly Agree
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16. Learning physics changes my ideas about how the world works.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

17. To learn physics, I only need to memorize solutions to sample problems.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

18. Reasoning skills used to understand physics can be helpful to me in my everyday life.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

19. I find carefully analyzing only a few problems in detail is a good way for me to learn physics.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

20. I can usually figure out a way to solve physics problems.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

21. To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

22. It is possible to explain physics ideas without mathematical formulas.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

23. When I solve a physics problem, I explicitly think about which physics ideas apply to the problem.

Strongly Disagree	1	2	3	4	5	Strongly Agree
-------------------	---	---	---	---	---	----------------

24. Is there anything else you would like me to know?

APPENDIX D

INTRODUCTORY STATION LAB MONITORING CHART

INTRODUCTORY STATION LAB MONITORING CHART

- ✓ + = above-standard performance
- ✓ = standard performance
- ✓ - = below standard performance

[illegible]

APPENDIX E

WELLS STATION LAB INTERVIEW QUESTIONS

WELLS STATION LAB INTERVIEW QUESTIONS

Participation in this research is voluntary and participation or non-participation will not affect your grade or class standing in any way.

1. Did you find the introductory station labs to be helpful? Why or why not?
2. When during the rest of the course were you most likely to think about the station labs? Explain why.
3. How many times during the rest of the unit did you find yourself referring back to or reflecting on something you did or saw in the introductory station labs?
4. Did you ever discuss something you saw or did during a station lab with someone outside of class? Can you describe your discussion?
5. How many times did you discuss something you saw or did during a station lab with someone outside of class?
6. What types of experiences/hobbies outside of class time have you had that are related to physics?
7. Have you thought about the physics you experience in everyday life that relates to the unit of study? Can you elaborate?
8. On a scale from 1-5, with 1 being not at all and 5 being a lot, rate how have these extracurricular experiences have increased your interest in studying physics.
9. On a scale from 1-5, with 1 being not at all and 5 being a lot, rate how your experiences during introductory station labs have increased your interest in studying physics.
10. Is there anything else you would like me to know?

APPENDIX F

WELLS POST TREATMENT INTERVIEW QUESTIONS

WELLS POST-TREATMENT INTERVIEW QUESTIONS

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. Do you think about the physics you experience in your everyday life? Can you elaborate?
2. About how many times did you relate your understanding of physics with something you saw or did outside of class? Can you elaborate?
3. For each unit completed, rate on a 1 to 5 scale, 1 being never and 5 being several, the number of times you related something you learned in class to something you experienced outside of class:
 - Forces/Inclined Planes/Connected objects
 - Energy/Momentum/Collisions
 - Projectiles/Circular Motion/Simple Harmonic motion
 - Gravitational, Electric and Magnetic Fields
4. Do you find yourself wondering why something works the way it does? Can you elaborate?
5. Has learning more about physics increased/decreased the amount of questioning you do, or has it remained about the same?
6. Do you find that your understanding of physics has had an impact on how you experience the world? Can you elaborate?
7. Is there anything else you would like me to know?