

THE EFFECT OF PROJECT-BASED LEARNING ON STUDENT ENGAGEMENT
AND ATTITUDE IN THE SCIENCE CLASSROOM

by

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ABSTRACT

Part of a science education is developing an understanding of ways to increase student engagement in the science classroom. The twenty-first century science classroom involves student engagement in Project-Based Learning, in which students investigate natural phenomena through practices utilized by scientists and engineers. This study investigated how a Project-Based Learning curriculum impacts student engagement and attitude in the science classroom. The study also investigated the effect on students' attitudes towards learning, the role that student choice and projects makes in the students' perspective of their learning. The results indicated that students found the Project-Based Learning classes to be engaging and created a positive attitude amongst the students. This action research showed the importance of implementing a Project-Based Learning curriculum in science classes.

INTRODUCTION AND BACKGROUND

This study was conducted at a medium sized boarding school in Watertown, Connecticut, about two hours Northwest of New York City. It is a diverse school with students from 33 states and 44 countries, leading to many different languages, cultures and educational backgrounds. Despite being a boarding school, Taft is economically diverse with students who fit into every social and economic category. Some of our students come from challenging backgrounds and foreign countries such as Zimbabwe, and others come from very affluent families. Of the 575 students enrolled in school, roughly 480 of them live on campus, along with 80% of the faculty. On average our math and science classes have about 14 students, however classes may be as small as eight students (P. Frew, personal correspondence March 15, 2017).

Overall, the curriculum of the school places a great deal of emphasis on grades and course level, which often includes advanced placement courses. In reviewing the lower level courses and seeing the students who have not excelled at the level above and have drop down has forced the science department to evaluate the way in which we view learning, to see if an alternative method is more effective. The students tend to look at learning only based on the grade that they earn or the level class that they are in. Rarely do the students truly see the value in understanding the material that is being covered. Instead, they focus only on what they need to know to pass the next test with a good grade. In looking at the students' attitudes and drawing on my own past experience, it was clear that I needed to find a better way to connect the students with the material and challenge them to engage in the content in ways that they have not previously done.

Researching project-based physics curricula has lead me to believe that changing the way I teach our lower level courses, in moving from a more traditional content driven course to a more project-based course, could increase student understanding and engagement. Based on the work that I have done in other courses with project-based learning, I strongly believed that this would help the students connect the content to the world around them and engage the material. My hope was that students would see the value in what they are learning and begin to focus more on the learning process, rather than simply on their end of unit grade.

My experience and reflection have led to the formation of my focus question, what impact does project-based learning have on science students' attitude and engagement levels? In addition, the following sub-questions were addressed, 1) what role do laboratory investigations or projects play in student engagement? 2) how does having a choice in topic or approach impact student attitude? 3) does PBL help shift the focus of learning from the end grade to more authentic learning?

CONCEPTUAL FRAMEWORK

Project-based learning (PBL) currently is one of the hot topics in the education community, as it has been shown to increase student engagement through authentic learning. Project-based learning consists of teaching by providing students with complex, ill-defined but real-world problems that draw them in organically (Azer, Guerrero, & Walsh, 2013; Duda, 2014). Over the years, the educators have seen the value in project-based learning. The practice has transitioned from medical education to a mainstream pedagogical approach that is being used in all forms of education ranging from

kindergarten to university. There are many different approaches to a project-based learning class that include a traditional class problem approach, students on stage, place-based learning, and open-ended projects. Each of the approaches offers its own unique features that will be highlighted throughout the following section.

Despite being student centered learning, it is important to remember that even the best students may struggle if left to their own devices. It is important for the teacher to implement scaffolding to build the knowledge base needed to tackle a big project. When first developing a PBL class, it is necessary for the teacher to provide the scaffolding required to support the students as they move through the course. Scaffolding can be done in a number of different ways, but it is important that the learning objectives are clearly laid out for the students. Some teachers prefer to use a weekly or unit packet that includes handouts, exercises, lecture notes, or videos that guide the students through the key concepts needed for a project (Bell, 2010; Duda, 2014). To many, this seems very similar to the traditional direct instruction style teaching that is often used in a class, which is true, but behind it all is a project that is often presented at the beginning of a unit as a hook. The goal of utilizing a project is to introduce students to real-world applications and show them why they are learning the material (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2013; Sahin & Top, 2015). Once the students are hooked, the authentic learning takes place, where students engage in/with the material and truly learn. Throughout the project, students take ownership of class time and as a result, take ownership of their education. The overall structure of a student-centered class remains a

constant in all PBL curriculum and lends itself to Science-Technology-Engineering-Math education (STEM).

With a significant focus on STEM, project-based learning has been pushed to the forefront in implementing a curriculum geared to strengthen the United States performance in the STEM disciplines. One approach that has proven to be successful is STEM Students on the Stage (SOS), which aims to maintain the focus on standards-based and student-centered teaching, while enriching and extending the learning of the students through PBL projects. In contrast to other conventional PBL approaches, students have to complete multiple projects, including several chapter projects and a yearlong advanced project. The students are assigned two chapter projects each semester and these projects are completed in-class in groups of three or four students. In addition to the smaller in class projects, the students must also complete one interdisciplinary project from either math or science, as well as an assignment for social studies and ELA. The year-long projects are completed outside of the classroom and technology is integrated in each step. Another requirement of the yearlong project is the creation of a brochure summarizing the student's project, including QR codes of a student's website, and a digital presentation of the final product (Sahin et al., 2015). Figure 1 below shows the student perspective on how the STEM SOS process looks (Sahin et al., 2015).

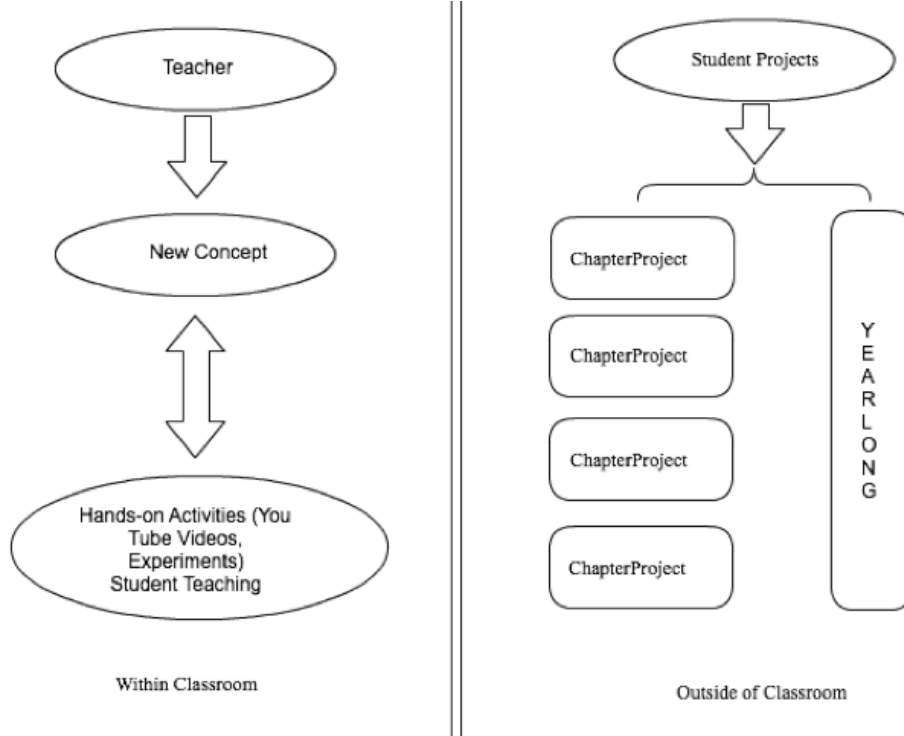


Figure 1. Student perspective on STEM SOS model.

In this model teacher-directed learning occurs initially, with each new unit, as it lays the foundation for new concepts. Within the classroom, the teacher presents a new concept and lays the foundations needed for the students to complete a hands-on activity. The activities are designed to increase student engagement and learning. Activities range from producing YouTube videos to experiments. After completing the hands-on activity, the students then become teachers and present the material to the rest of the class. The students prepare experiments or hands-on activities for the class that relate to the content within each unit. The benefits for the students and a theory map for STEM SOS can be seen in Figures 2 and 3 (Sahin et al., 2015).

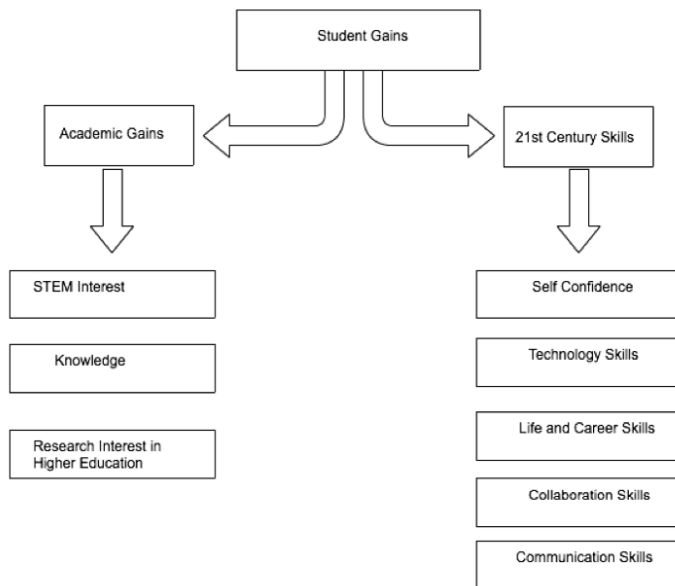


Figure 2. Student gains with SOS model.

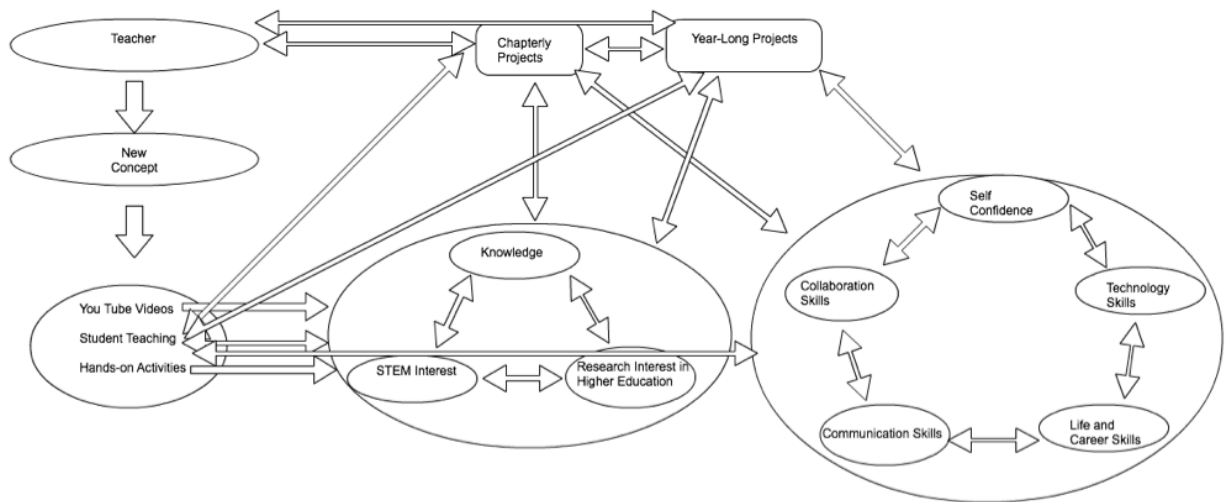


Figure 3. Grounded Theory Map of STEM SOS.

The STEM SOS model is an example of a PBL curriculum that helps students increase both academic and 21st century workforce skills. The model suggests two core elements, either student or teacher directed learning and chapter and yearlong projects

(Sahin et al., 2015, Bell, 2010). This is just one of the many theories that exist when it comes to PBL.

Place-based learning uses that same framework as all Project-Based Learning approaches but aims to create a learning environment that is personally relevant and meaningful. Depending on the location of the school or the student's home region, the projects utilized in Place-based learning take a unique twist to draw upon the connections to the real world to engage the students. Place-based learning as a concept has been around for a long time, but only recently has it been implemented to deliberately capitalize on knowledge manifested in the local community and uses it as a springboard to introduce concepts in multiple content areas through hands-on, real world experiences (Busari, 2000; Harada, 2016). At the core of place-based education is the idea that education grounded in a place enables the student to see how it connects to their own experiences.

Service learning is an extension of place-based learning, where the students apply the knowledge and skills that they have learned in school to a real-life community problem. In a service learning environment, the students look to develop real-world solutions to problems or services that benefit mankind (Ricke, 2018). Newman, Dantzler, and Coleman (2015) provided the following steps to organize instruction in a service learning-based class:

1. Investigation: Identify a local, national or global need to investigate.
2. Preparation and Planning: Develop a strategy for change and a common vision for success.
3. Action: Implement the service activity to make a difference.
4. Reflection: Think about how the service and learning relate to the student, the student's community, and student's future.

5. Demonstration and Celebration: Showcase the student's results and celebrate the outcome (Newman et al., 2015, p. 50).

The five steps to a service-based project are important, as they allow the student to take ownership of their education. The teacher acts as more of a guide to ensure that the students are meeting the pre-determined standards along the way. Results from service-based learning have shown gains in academic achievement, academic engagement, civic responsibility, and resiliency (Doddington, 2014; Newman et al., 2015).

Project-based learning has a third approach that some STEM programs in particular are using, which is known as open-ended projects. With open-ended projects, the students are empowered to develop their own projects, provided they satisfy standards. Although daunting at times, the open-ended project design yields the best results, because it fosters the highest level of thinking, promotes engagement, and increases student interest. With an open-ended project, the students are given the freedom to develop and create all aspects of a project, based on existing knowledge, interest, and hobbies. The student projects should be structured such that they meet the standards of the course and cumulate with a presentation to a larger audience that may include other classes, faculty, or members of the community. The presentation format should remain open to be determined by the students. Open-ended projects may be the most challenging approach to project-based learning to success fully execute (Case, 2007; Nichols, 2016).

When planning on implementing an open-ended project there are several things that a teacher must consider. The space in which the project will take place is one of the most significant attributes to successfully implementing an open-ended project. Having a space that ignites student collaboration and higher-level thinking is ideal in promoting

student success. Creating an atmosphere where students have atypical spaces to brainstorm and collaborate will foster solutions involving more depth and purpose. Having a student pick a problem is often challenging. When a student tries to design a solution they often fail to produce a prototype, or simply design a product that they thought would be useful, but fail to gain any real knowledge (Hanney, & Savin-Baden, 2013; Nichols, 2016). It falls on the teacher to facilitate the selection of a problem and not have the students design a solution. The teacher needs to guide the process and can often help facilitate the process by having the student reflect on interests or activities and problems related to them. The students should then research the problem, and work alone to generate possible solutions. When working in pairs, students should first generate ideas alone and then later come together as a group to determine the best solution. Once the solution concept is chosen the students then begin to create a prototype, followed by testing the prototype. After any redesign of the original prototype is complete the students present the project in a format that they feel best explains both the problem and the solution.

With education needing to adapt to ensure that students graduate with the 21st century skills of critical thinking, communication, creativity, and collaboration, educational curricula must change to meet the needs (Nichols, 2016). Project-based learning is one approach that has proven successful in teaching 21st century skills, increasing engagement and authentic learning. There are several approaches to project-based learning ranging from the more traditional approach grounded in scaffolding laid out by the teacher to work through several concepts or chapters, to the wide-open nature

of open-ended projects. Project-based learning is grounded in the idea that relating the education of students to real-world problems or situations will help connect the concepts to a student's life (Rivero, 2017). Project-based learning offers a unique way to engage the students, providing them with opportunities to learn content through problem solving, real world applications and the ability to have a positive impact in the community.

METHODOLOGY

To incorporate project-based learning (PBL) into the science curriculum, the second semester Introduction to Engineering course was designed and taught using a more traditional approach grounded in a scaffolding designed to guide the students throughout the process. The PBL course was based on a performance engineering project involving Traxxis remote controlled cars, which were used as the hook to get the students engaged in the material being taught. The students were split into teams of two or three and given a car for the semester. Throughout the semester, the students had to perform experiments to gauge the effects of different adjustments on the car, and to determine the optimal car set-up for a given challenge. The students were asked to use statistical measures to determine the optimal set-up of the car, based on the telemetry that they gathered using the Traxxis app that communicates with the car (Appendix A). The competitions throughout the semester included the following; indoor course, winter hill climb, fastest $\frac{1}{4}$ mile on a track, spring hill climb and rally track circuit. Each of the challenges served as a component of the scaffolding as they were selected to teach the impact that different adjustments have on the car's performance. In varying the surface and requirements the students were required to carefully record and understand how the changes impacted the cars performance and learn to manage their time efficiently as the

length of time for each challenge varied depending on the complexity of the surface. However, the length of time on each challenge was designed to benefit the students who learned to efficiently manage their time. These activities provided students with the opportunity to use experimental design and analytical skills to make decisions in regards to optimizing the performance of the car based on the data collected. The research methodology for this project received an exemption by Montana State University's Internal Review Board and compliance for working with human subjects was maintained (Appendix B).

Two additional Project-Based Learning classes were also studied to determine the engagement and attitude of the students. The other two courses were Scientific Ethics, taught by Shannon Guidotti to a class of nine seniors. Forensic Science was taught by Mike McAloon, to a class of eleven junior and seniors. The Scientific Ethics focuses on important figures in scientific ethics from Kant to Caplan. Combining historic cases and current events, the approach was case-study based, using many forms of media that may include journals, magazines, newspapers, novels, and even movies. Possible topics included pharmaceutical research and marketing, environmental law, regulation of chemical use in everyday products, and testing of nuclear bombs. The goal of the class was to provide students with a framework to analyze difficult situations in science, using their own moral compasses and theories in ethics as guides. The Forensic course introduces students to the principles and practices found in the field, which draws from the biological and physical sciences. The course began by examining the theories and concepts necessary to effectively examine, analyze, and reconstruct a major crime scene.

Students also studied trace evidence and how it is analyzed, compared, interpreted, and used in criminal investigations. Types of trace evidence that were discussed included glass, paint, hair, fiber, and fingerprints. Case studies of actual crimes and trials were discussed to illustrate how the science and techniques may be used in the real world. This course was taught through lectures, laboratory work, and student presentations. All of the courses were upper school science electives drawing from a similar population of the student body in regards to past science performance and general attitude towards science.

To measure the impact the different PBL curriculums had on the students' engagement and attitude towards science, the students in the semester classes took the survey, Engagement and Attitude in the Science Classroom, during the first full week of classes in January (Appendix C) and the full schedule can be seen in Table 1.

Table 1
Survey, Observation and Interview Schedule

Class	Date Survey Taken	Interview Dates	Class Observations
Introduction to Engineering	01/6/2018	2/21/2018 through 3/03/2018	01/31/2018
Forensics	01/07/2018	2/21/2018 through 3/03/2018	02/12/2018
Scientific Ethics	01/07/2018	2/21/2018 through 3/03/2018	02/24/2018

The anonymous survey was distributed through google forms, and the students could answer the Likert questions with *strongly disagree*, *disagree*, *neutral*, *agree*, and

strongly agree. A random sample of the students in the 3 courses were then interviewed in late February and early March (Appendix D).

Throughout the winter semester, three teachers from the Taft School at The Taft School, observed the PBL classes and two first year physics classes to collect data on the student engagement through observation using an *Engagement Rubric* (Appendix E). The two first year physics classes were observed to offer some comparative data in regards to the engagement level of the students. The majority of the students in the PBL courses had previously taken physics at Taft and it was important to see how student engagement changes based on the way in which the content was presented. The first year physics classes each had fourteen students with a roughly fifty-fifty gender breakdown and were made up of freshman and sophomores. The data collected during the observations were presented side by side in bar charts to look for any associations; that existed between the students' attitude and students' engagement level.

The variety of data collection tools used to answer the primary and secondary questions are outlined in Table 2.

Table 2
Data Triangulation Matrix

Data Source	Questions			
	<i>Focus Question: How does project based learning have on science students' attitude and engagement levels?</i>	<i>Secondary Question: What impact do laboratory investigations or projects play in student engagement?</i>	<i>Secondary Question: How does having a choice in topic or approach impact student attitude?</i>	<i>Secondary Question: Does PBL help shift the focus of learning from the end grade to more authentic learning?</i>
Survey: Engagement and Attitude in the Science Classroom	X	X	X	X
Student Interviews	X	X	X	X
<i>Engagement Rubric</i>	X	X	X	X

DATA AND ANALYSIS

The data collected on the impact that Project-Based Learning in the science classroom has on student engagement and attitude, was analyzed both quantitatively and qualitatively to determine if any trends existed.

The students in the three PBL classes were administered the seven-question survey where they commented on their attitude and engagement both in class and on labs, projects and tests. The data represented in Figure 4, revealed that 54.5% of the students strongly agreed with the survey question, "In general I have a positive attitude towards science". In addition to the 54.5% that strongly agree an additional 22.7% agreed with this and 18.2% were neutral in regards to the statement. Only one student who filled out

the survey strongly disagreed with the statement and made up 4.5% of the population studied.

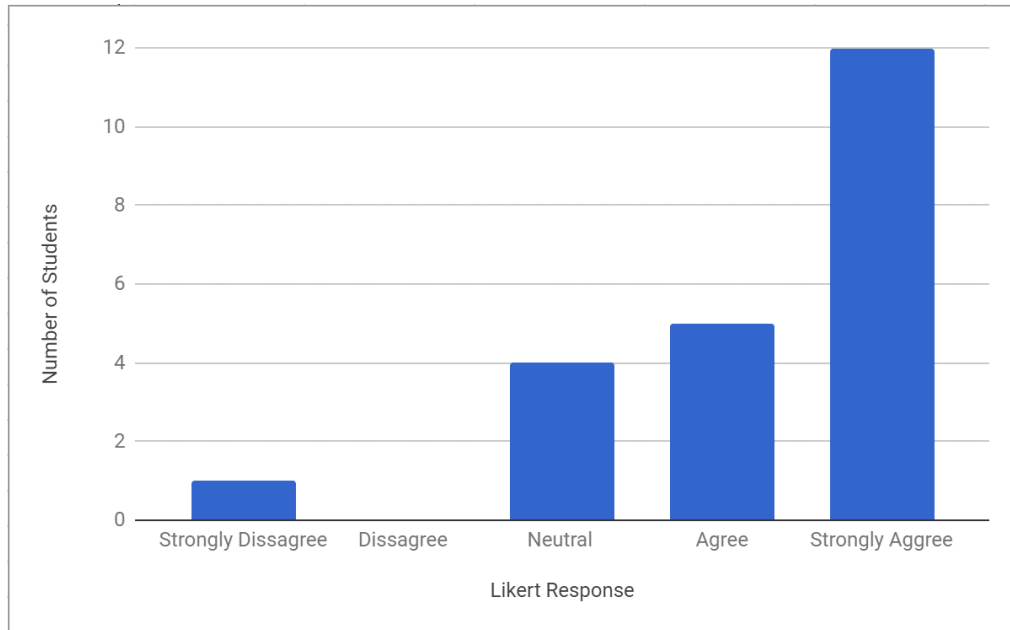


Figure 4. Survey question: “In general I have a positive attitude towards science”, (N=22).

The students’ data in Figure 5, further supported the results in regards to having a positive attitude with a follow up survey question. For the survey question, “I generally look forward to going to science class,” 50% of the students strongly agreed with the statement. An additional 27.3% agreed with the statement and 13.6% where neutral on the going to science class. Only two of the 22 students either disagreed or strongly disagreed with the statement, making up 9% of the data.

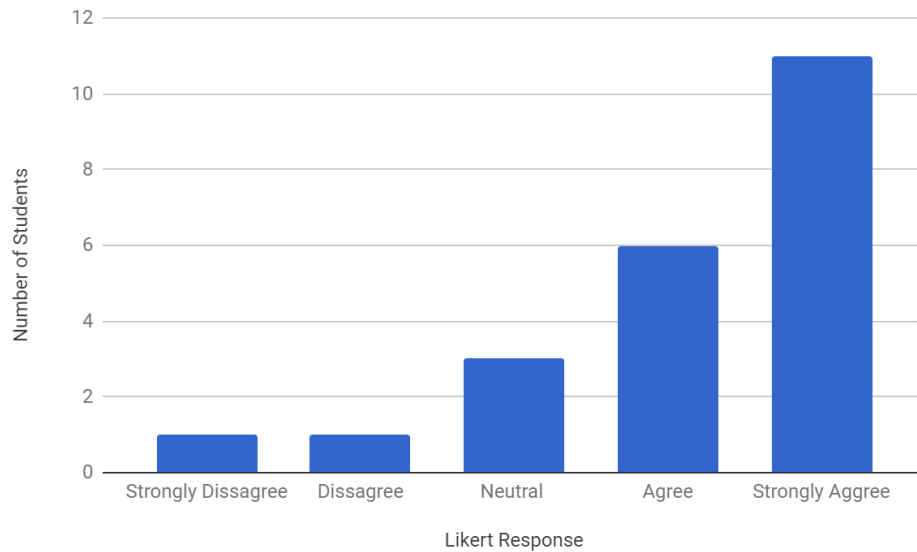


Figure 5. Survey Question: "I generally look forward to science class", (N=22).

The qualitative data that was collected from the student interviews supported the survey in regards to the generally having a positive outlook on science. The first question on the interview asked students to discuss their attitudes about science classes and why they felt that way. In total 16 students were interviewed during the process and the trends from the first question of the interview can be found in Figures 6 and 7.

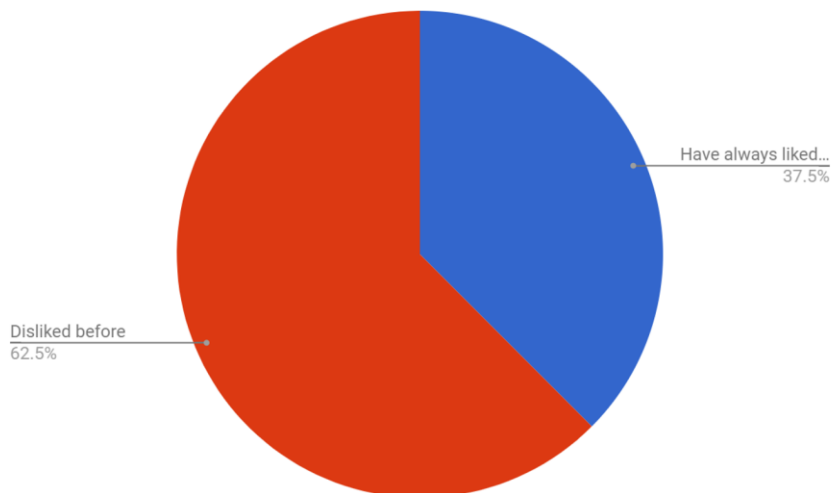


Figure 6. Interview Question: "In general my attitude towards science", (N=16).

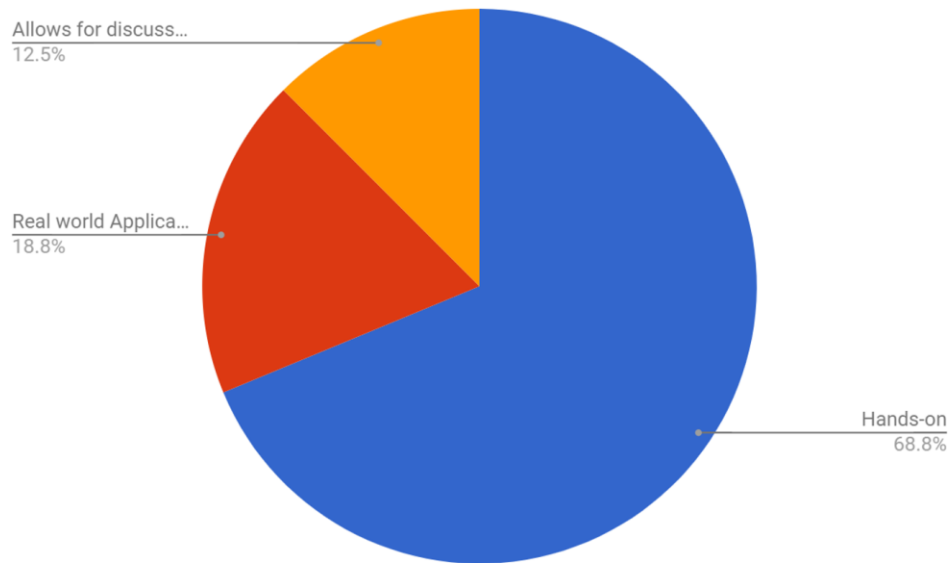


Figure 7. Interview Question: “Explain, in general my attitude towards science is”, (N=16).

The results from the interview revealed that 62.5% of the students who look forward to going to science class did not enjoy science prior to taking one of three classes studied during the second semester. The largest reason for the change in attitude is that the classes employed a hands-on focus and 68.8% of the students found that to be a significant factor in their overall enjoyment of science. The two other main reasons for the enjoyment of the classes were real world applications, 18.8%, and allowed for discussion, 12.5%.

The data for the second question involving students’ opinion about the remaining engaged in class at least 75% of the time, revealed that 63.3% of the students’ characterized their engagement as such. An additional 13.6% only agreed with the statement and 13.6% remained neutral to being engaged 75% of the time. A total of 9%

of the students' surveyed did not feel that they are engaged at least 75% of the time. The data is represented on Figure 8.

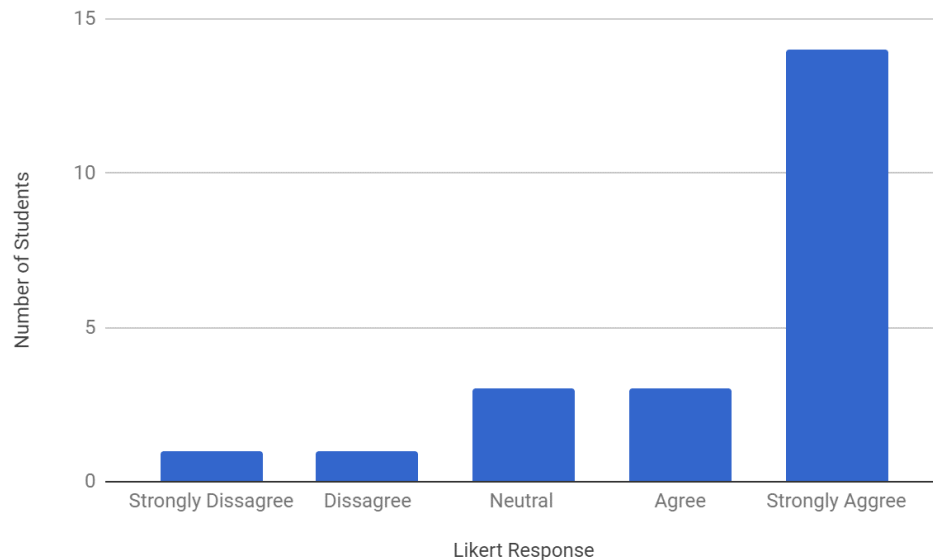


Figure 8. Survey Question: “In general in science class I am engaged in the material at least 75% of the time”, (N=22).

The interviews revealed some clarity as to why so many of the students believed that they are highly engaged during class time. The students were able to explain why they enjoyed going to class. One of the students responded with, “Class is more about you and your partners trying to solve a problem or learn something together, as it is coming from you. The class is student driven and you get the chance to learn for yourself and not just spit info back at the teacher.” Another student followed with a similar statement saying, “It is easier to zone out in a traditional class, in a project class you cannot zone out and are always willing to try something new.” To gain a better understanding as to why the students felt the PBL classes were more engaging the

interview responses were broken down into three categories (a) student driven, (b) active learning, and (c) having fun while learning. The results can be found in Figure 9.

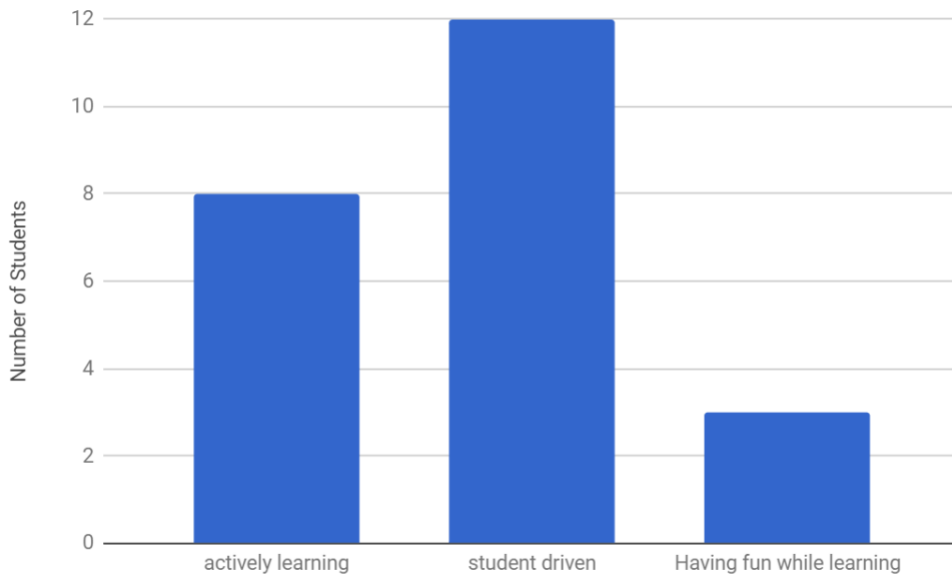


Figure 9. Interview Question: “Explain why you enjoy science class”, (N=16).

An additional section of data collected on the students was related to how the students felt about their work on labs and projects. The survey asked students to select the ending that best finishes the statement, “When working on labs or projects I”. The data revealed that 13.6% of the students struggle to understand the purpose of the lab or project. An additional 54.6% of the students feel that they are able to accurately collect the data and complete the process. Of the twenty two students that took the survey, seven or 31.8%, of the students’ were excited about the work and found themselves putting in extra effort, the results can be seen in Figure 10.

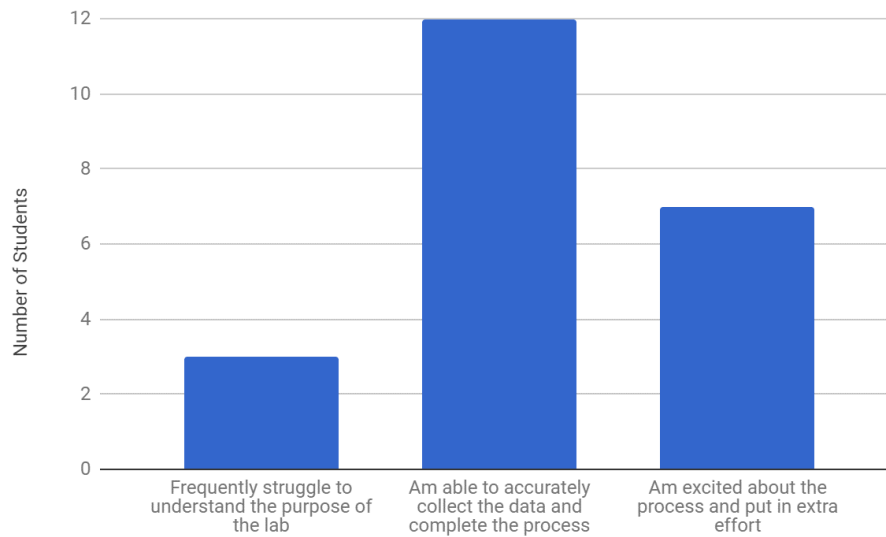


Figure 10. Survey Question: “When working on labs or projects I”, (N=22).

In taking a deeper look at the students’ opinion on whether or not labs or projects help in their learning, the data continued to support the students’ responses from the interview in regards to the hands-on nature of the science classes being a key reason for enjoyment. The data revealed that 9% of the students either disagreed or strongly agreed with the idea that the use of labs or projects helped in their learning. The student responses revealed that 72.8% of the students believe that labs and projects help in their learning of science. The final group of four students had no opinion either way on the impact of a lab or project on their learning. Figure 11, below shows the distribution of student opinions.

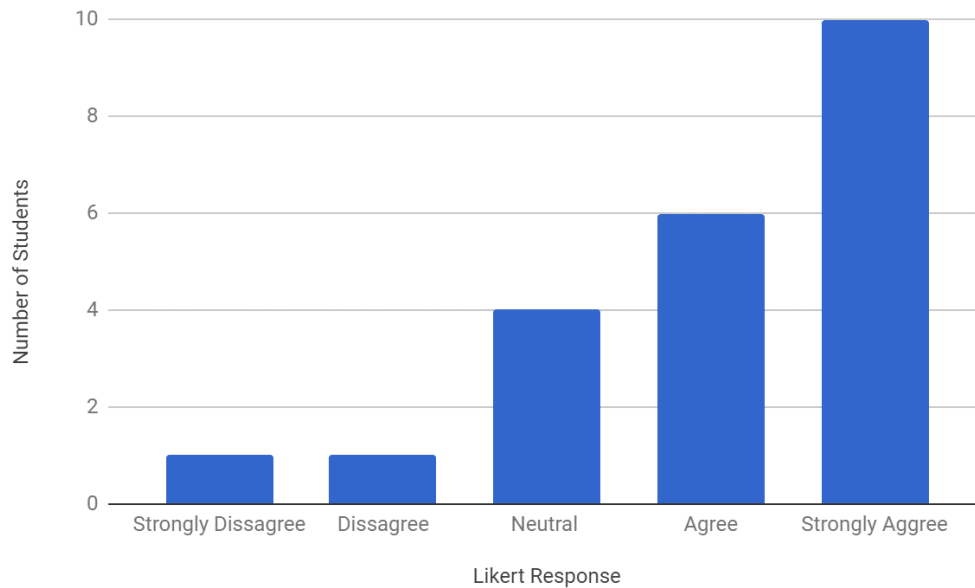


Figure 11. Survey Question: “The use of projects and/or labs helps in my learning”, (N=22).

The results from the previous question support the idea that the students would rather have a project or presentation at the end of a unit as compared to test. The data revealed that 81.8% of the students would rather do a presentation of project to show an understanding of the material at the end of the unit, as seen in Figure 12.

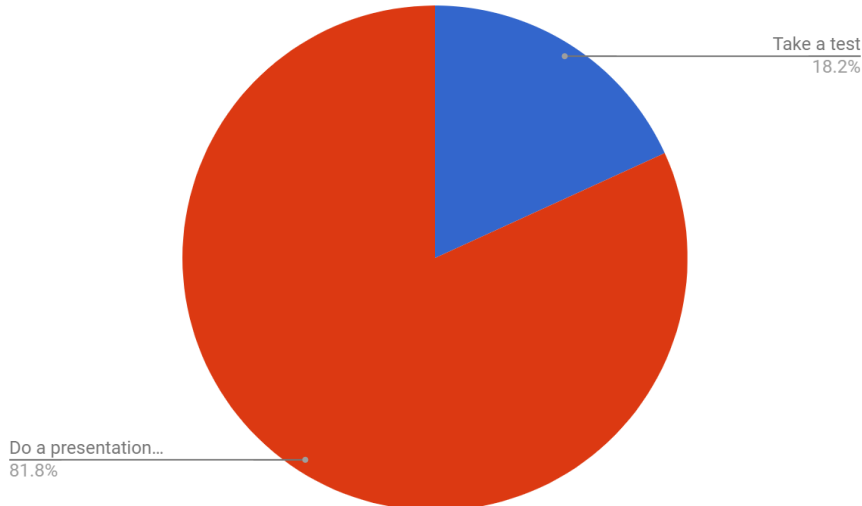


Figure 12. Survey question: “At the end of a unit I would rather”, (N=22).

To try and better understand why the students felt so strongly in favor of the projects as compared to a test, students were asked to answer this question in both the survey and the interview. In the survey, the students were asked to classify how they felt when given choices in a project. It revealed that 40.9% of the students enjoyed having a choice, but generally took the simple route that was most comfortable. Of the students surveyed, 13.6% felt overwhelmed and wished that they could be told exactly what to do on the assignment. This was in stark contrast to the final 45.5% of students who were excited by the choice as they were able to be creative and take ownership of their work. The interview process supported the data collected in the survey, and indicated that students not only liked having a project at the end of a unit, but believed that they learned more. One student said, “In Scientific Ethics I have found greater success because learning is tailored towards personal interest. It enables you to select a topic that interests you, so you actually work harder on it and not resentful that you have to do a project.” Another student explained that in having set goals and appropriate scaffolding that, “with no defined steps with each challenge you need to develop a deeper understanding of the material.” The three main themes that emerged from the interview are that 27.3% of the students believed that having the ability to select the best approach to learning the material was powerful. An additional 40.9%, liked the projects because they had to prove that they learned something. The final category of having a choice to select a topic that interests you accounted for 31.8% of the students.

The final question of the interview asked the student if the PBL curriculum allowed them to focus more on the learning process and less on the grade. What the data

revealed that 13 of the 16 students interviewed or 81.3% of the students are more focused on learning and effort than on the grade. Only 18.8% of the students had a greater focus on the final grade than the overall learning process. One student stated, “Don’t worry about the grade, because if the effort is there then the grade will reflect it.” Another student had the following to say, “Trying to learn for learnings sake, want to learn. Competition makes it fun and is an incentive that drives you. Finding ways to take care of the car to get every ounce of performance out of the car. In any case you can disengage in class, but higher engagement in a hands on class, because you do not have to go back to relearn it and the time table is important as you have to be efficient during class time.”

In addition to the interviews and student surveys, the three teachers filled out a class observation rubric that examined student engagement levels. The observation rubric was compared to that of two first year physics classes, which was a required class. The observation rubric looked at the following five categories: Listening, Note Taking, Engaged Computer use, Engaged Student Interaction, Engaged Interaction with the Instructor. The following bar charts show how the different observational ratings for each of the classes, with a 5 being highest engagement and 1 being lowest. The results Figure 13, show that the listening during lecture is highest in the three PBL courses, with an average rating of 4 compared to 2 for the physics class.

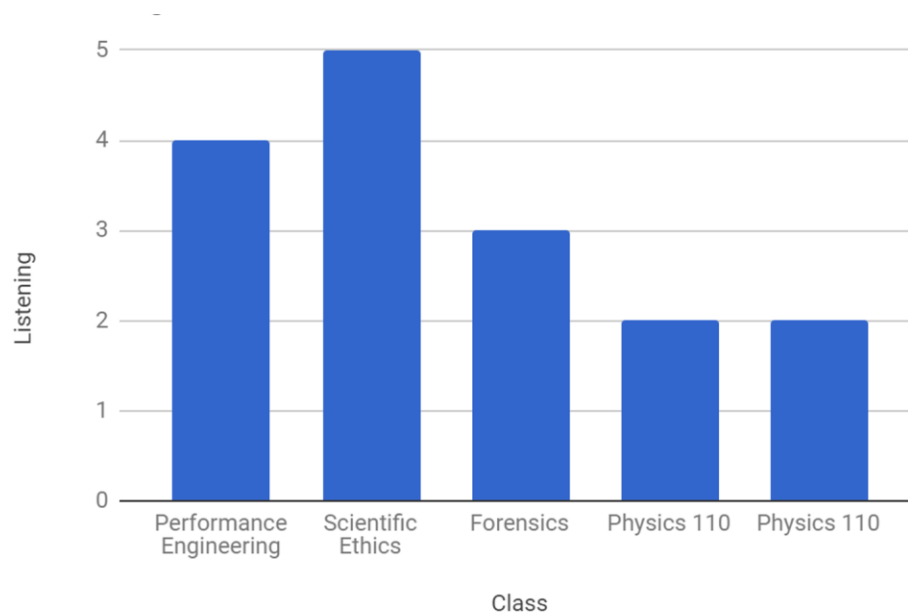


Figure 13. Observational category: Listening ($N=5$).

Based on the observational data the difference between classes when it comes to note taking becomes much smaller. The average score for the PBL classes is 4.3, compared to 3 for the physics classes. When looking at engagement with computer usage the data reveals that the student engagement level drops with all classes to an average of 3.33 for the PBL and 2.0 for the Physics classes. The results from the observational study are supported by the comments that the students made throughout the interview process. One student stated “it is easier to zone out in a traditional class”, and another student said “during lecture it is easy to zone out, because you have to go back and relearn the material anyway.” Figure 14 and 15, below represent the data collected during the observations.

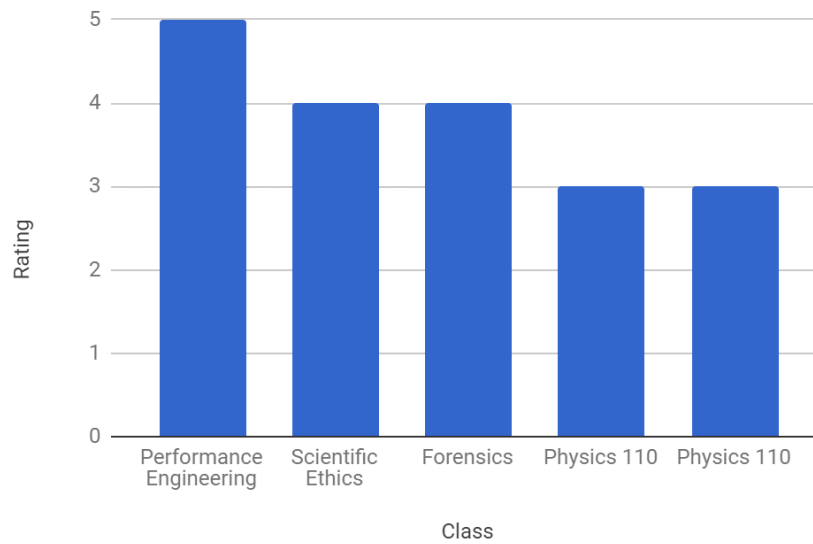


Figure 14. Observational Category: Note Taking (N=5).

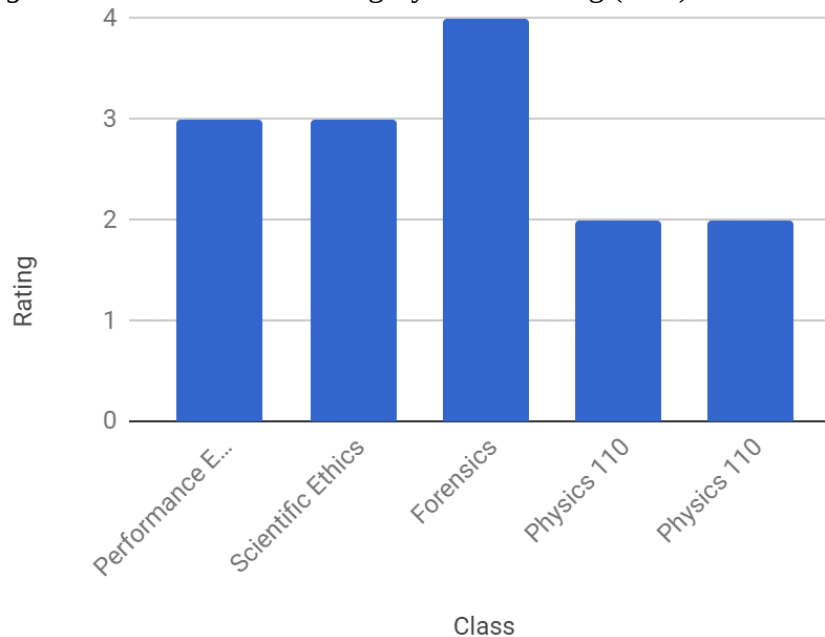


Figure 15. Observational Category: Engaged Computer Usage (N=5).

The final two categories on the observational rubric are engaged student interaction and engaged interaction with the instructor. The data shows that the PBL classes have a higher level of engagement than the traditional physics classes. The average rating for the PBL classes for engaged student interaction is a 5, compared to 3

for the physics classes. For engaged interaction with the instructor the PBL classes had an average rating of 4.33; compared to 2.5 for the physics classes. The student responses support the observations, as one student put it, “having a group helps us learn by being able to talk through our different ideas, and then we are able to use the teacher as a resource as needed.”

Table 3

Engaged Student Interaction w\With Students and Instructor

Class	Engaged student to student interaction	Engaged interaction with instructor
PBL Classes	5	4.33
Physics Classes	3	2.5

INTERPRETATION AND CONCLUSION

The goal of this research was to gain a better understanding of the impact that a PBL curriculum plays on students’ engagement and attitude in regards to science. Other aspects of the research were designed to see how the use of laboratories and projects impacted the students’ perception of their learning, gain a better understanding of how having choice within the topics that they study or in the way that they are able to approach a project, and if a PBL curriculum shifts the focus of learning from receiving a good grade towards more authentic learning. A number of qualitative techniques were used to collect the data and data analysis tools were applied.

The data collected with the Engagement and Attitude in the Science Classroom survey, interviews and the Engagement Rubric, that a PBL curriculum has a positive impact on student engagement and attitude towards science. The survey revealed that

77.2% of the students have a positive attitude when it comes to science. What is more revealing about the impact of the PBL classes is that of the 16 students interviewed 62.5% of the students previously disliked science and now not only enjoy science class, but look forward to going to class. The students' key reasons for the change in attitude is that class has become more hands-on, they can see the real world applications, and the classes allow for open discussion of the content. To further support the idea that students who enjoy and look forward to going to class are more engaged 76.9% of the students in a PBL class believe that they are engaged at least 75% of the time. When asked for the reason behind the high level of engagement, the students felt that the key reasons behind the engagement level were actively learning, having fun while learning, and the idea that the class was student driven. This can be supported with what was seen during the observations, as student engagement level was lowest when allowed to follow a lecture on the computer as the rating for engagement dropped below 4 to 3.33, which is lower than the 4.33 with listening, and student engagement with other students and instructor for those classes. The data collected shows that the students in the PBL based classes generally have a positive attitude towards class and feel that they are engaged during class time.

Using the data collected from the Engagement and Attitude in the Science Classroom survey and interviews the impact on laboratories and projects on student learning became clear. The data showed that 72.8% of the students feel that laboratories help with learning and 81.8% would rather have a presentation to prove that they learned the material than take a test. The most common reason for the support of labs came from

the idea that it was active learning and they needed to be hands-on during class time. The students' strongly stated during the interview process that when they are active they are less likely to zone out. They also felt that with a presentation they have to gain a better understanding of the material to prove that they have mastered the skills or concepts, compared to a test when they can simply regurgitate the material that was given to them by the teacher.

The data revealed that students feel that having choice in their learning plays an important role in their overall enjoyment and engagement levels with a class. In total 86.4% of the students found that having choice in either the material studied or the best way to approach a problem or project was a powerful tool, because it empowered them to take ownership of their learning. Through the interview process one student stated, "You learn more because you have room for trial and error, with a clear goal and some expectations we have the ability to plan and make mistakes along the way as we determine the best practice." The students found that being challenged to do more than just follow carefully laid out steps was important for their learning as they became more focused on the day to day activity than the final outcome. Another common theme that came out of the data collection around having student choice is that the students enjoyed being given the power to select different topics to research. Of the students interviewed the idea of a student driven class, in which they have the power to make choices, has them excited and working harder to understand the material.

The data collected showed that the students believe that having a PBL based curriculum shifts the focus of class from the grade to understanding the material on the

project. One student stated, “I am not worried about the grade, as I know that if I put the effort into the project then the grade will follow.” During the interview process the data collected showed that 81.3% of the students said that they were less worried about the final grade and more interested in learning the material. Given the population of the school, this is an important value, as Taft is a highly competitive school where a great deal of emphasis is put on academic performance by both the students and families.

The data collected with the Engagement and Attitude in the Science Classroom survey, interviews and the Engagement Rubric showed that a PBL curriculum does have a positive impact on student engagement and attitude in the science classroom. The data revealed that the students liked going to class and remained engaged during class time. After having looked at the data the results indicate that it is important moving forward to include the positive aspects of a PBL class into the other classes taught within the science department at Taft, as the students increased engagement and positive attitude will further strengthen the work that is being done.

VALUE

This study which looked at the impact of PBL on students’ engagement and attitude impacted my teaching in a variety of ways. The purpose of this study was to see how a PBL curriculum would affect the students’ overall attitude and engagement levels in the science classroom. In looking at the students that I work with and thinking about the spring on campus I realized that I had to find ways to get the students excited and engaged during class time, as the traditional model of lecture and lab was not working. In discussing my situation with both other faculty and former students, I realized that a PBL

based class could be a great way to increase students' engagement and attitude towards science. The idea that many of the students involved in the study went from not liking science to having it be one of their favorite classes has helped to validate my work in developing the PBL curriculum.

The process of collecting data from the students has validated my previous thought, but one of the most powerful tools from the process is reflection. In working with the current PBL curriculum and hearing the feedback in regards to the other PBL classes I can see the aspects of it that are appealing to the students and will look to find ways to incorporate them into my other classes. One of the biggest take a ways is that students like doing science and not being lectured to about science, this is a central idea that I cannot only use myself, but also share with the rest of the science department.

Through the study, I learned that students enjoy having class be student centered. Students enjoy the opportunity to make mistakes and learn from the mistakes that they make. In looking ahead to next year, I will find ways to ensure that all of my classes have a larger student driven component, which enables the emphasis to shift from the end grade to focusing on the process. In a student driven class, the teacher becomes a resource to help guide the students and not the driver of the class. This was an important idea for me as often we get caught up in the idea that we need to cover more content, but having the students more excited about science may prove to be more beneficial in the long. This an area that I will have to spend more time researching and looking at.

Through this study, I have learned about the value in taking the time to listen to the students' voices and allow that to shape the way I teach. The reflections that I have

gained from my students will help me plan my future projects and lessons with the central ideas in mind, and hopefully make my classes more engaging and interesting for the students. The study has given me confidence as a teacher as it provided data to support what I believed to be true about a PBL curriculum. In implementing the study, I have become a better teacher and feel more equipped to design classes that bring out the best in my students.

REFERENCES CITED

- Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2013). How learning works: Seven research-based principles for smart teaching. *Teaching Theology & Religion*, (January), 94-96. Retrieved from Academic Search Complete database.
- Azer, S. A., Guerrero, A. P.S., & Walsh, A. (2013). Enhancing learning approaches: Practical tips for students and teachers. *Medical Teacher*, 35(6), 433-443. Retrieved from Academic Search Complete database.
- Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. *Clearing House*, 83(2), 39-43. Retrieved from Academic Search Complete database.
- Busari, J. O. (2000). Revisiting analogy as an educational tool-PBL and game of basketball. *Medical Education*, 34(12), 1029-1031. Retrieved from Academic Search Complete database.
- Case, J. (2007). Alienation and engagement: exploring students' experiences of studying engineering. *Alienation and engagement: exploring students' experiences of studying engineering*, 12(1), 119-133. Retrieved from Academic Search Complete database.
- Doddington, C. (2014). Philosophy, Art or Pedagogy? How should children experience education? *Educational Philosophy & Theory*, 46(11), 1258-1269. Retrieved from Academic Search Complete database.
- Duda, G. (2014). The Road to a Project-Based Classroom. *Change*, 46(6), 42-45. Retrieved from Academic Search Complete database.
- Hanney, R., & Savin-Baden, M. (2013). The problem of projects: understanding the theoretical underpinnings of project-led PBL. *London Review of Education*, 11(1), 7-19. Retrieved from Academic Search Complete database.
- Harada, V. (2016). The Power of Place-Based Learning. *Teacher Librarian*, 44(2), 8-12. Retrieved from EBSCO database.
- Newman, J., Dantzler, J., & Coleman, A. (2015). Science in Action: How Middle School Students Are Changing Their World Through STEM Service-Learning Projects. *Theory Into Practice*, 54(1), 47-54. Retrieved from EBSCO database.
- Nicholas, S. (2016). Open-Ended projects: 21st century learning in engineering education. *Technology & Engineering Teacher*, 76(3), 20-25. Retrieved from EBSCO database.

- Ricke, A. (2018). Finding the Right Fit: Helping Students Apply Theory to Service-Learning Contexts. *Journal of Experiential Education*, 41(1), 8-22. Retrieved from Academic Search Complete database.
- Rivero, V. (2017). Project-Based Learning. *Internet@Schools*, 24(Jan/Feb), 4-7. Retrieved from EBSCO database. (Accession No. 2156-843X)
- Sahin, A., & Top, N. (2015). STEM Students on the Stage (SOS): Promoting Student Voice and Choice in STEM Education Through an Interdisciplinary, Standards-focused, Project Based Learning Approach. *Journal of STEM Education: Innovations & Research*, 16(3), 24-33. Retrieved from EBSCO database.

APPENDICES

APPENDIX A
TRAXXIS APP



APPENDIX B
IBR APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Daniel Calore and Kate Solberg

FROM: Mark Quinn *Mark Quinn*
 Chair, Institutional Review Board for the Protection of Human Subjects

DATE: December 1, 2017

RE: "The Effect of Project-Based Learning on Student Engagement and Attitudes in the Science Classroom"
 [DC120117-EX]

The above research, described in your submission of December 1, 2017, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- _____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- _____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- _____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- _____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

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

APPENDIX C

ENGAGEMENT AND ATTITUDE IN THE SCIENCE CLASSROOM

Engagement and Attitude in Science Classroom

* Required

In general I have a positive attitude towards science. *

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

In general in science class I am engaged in the material at least 75% of the time. *

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

When working on labs/projects I *

- ☐ Frequently struggle to understand the purpose of the lab/project.
- ☐ Am able to accurately collect the data and and complete the process.
- ☐ Am excited about the work and find myself putting in extra effort.

The use of projects and or labs helps in my learning. *

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

I generally look forward to going to science class. *

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

When I have choices in my project or lab I find it to be *

- ☐ Overwhelming and I wish that I was told exactly what to do.
- ☐ Generally good, but I take the simple route that I am most comfortable with.
- ☐ Exciting as I am able to be creative and take ownership in the work that I am doing.

At the end of a unit I would rather *

- ☐ take a test
- ☐ Do a presentation or complete a project on the material.

APPENDIX D
STUDENT INTERVIEW QUESTIONS

Interview Questions

1. In general do you find yourself looking forward to science class? Explain
2. Did having choices in your project or in aspects of your project enable you to take more ownership in your learning?
3. In a project based class did you find that your learning was more authentic and less about the grade?

APPENDIX E
ENGAGEMENT RUBRIC

Listening	Student is looking at the instructor and is responsive to the lecture.	Unresponsive	Students are not responsive to lecture (e.g. they are sleeping or day dreaming, their eyes are not following lecture notes and they are unresponsive to instructor questions or cues)
Note Taking	Students are taking notes on in class material, they are annotating pre-printed notes or writing when instructor stresses something of importance	Off-Task	Students are working on homework or studying for another course, playing with phone, listening to music, or reading non-class related material
Engaged Computer Use	Student are following along with lecture on computer or taking class notes in a word processor or on the presentation	Disengaged Computer Use	Students are surfing web, playing games, chatting online, checking e-mail
Engaged Student Interaction	Students are is engaging with other students about class material (listening or explaining) (e.g. they are pointing at notes, or you can overhear them discussing material)	Disengaged Student Interaction	Students are engaging with other students about non-class related material (e.g. they are laughing, there is a constant back and forth between students)
Engaged interaction with the Instructor	Students are asking or answering a question or participating in in-class discussion	Distracted by Other Students	Students are observing other student(s) and are distracted by an off-task conversation or by another student's computer or phone