THE INFLUENCE OF PROJECT-BASED LEARNING ON STUDENT ENGAGEMENT AND ACHIEVEMENT

by

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ABSTRACT

This project exposed students to varying methods of project-based learning strategies throughout a specific unit. Quantitative assessments, surveys, student observations, and focus groups were used to collect data. The experimental group consisted of three class periods that were exposed to the project-based learning strategies, while the control group consisted of three other class periods that continued their traditional unit activities. The results suggested that more students score in the proficient range through project-based learning.

INTRODUCTION AND BACKGROUND

I teach at North Polk High School, a suburban public school, in central Iowa. The North Polk Community School District includes the towns of Polk City, Alleman, Elkhart, Sheldahl, and northern Ankeny. The combined population total of these towns is 6,667, with Polk City making up the majority of population at 5,189. The median household incomes for the towns that make up the district range from $64,479 to $105,699. This range in median household incomes is a direct correlation to our wide range of parent/guardian careers. Careers in our communities range from farmer to factory worker to downtown Des Moines commuting financial advisors.

North Polk High School contains grades 9-12 and currently educates 471 students. The student-teacher ratio is 17 to 1. North Polk High School has a free or reduced lunch rate of 10.7%, which ranks in the top 1.3% statewide, meaning the vast majority of our students have a high socioeconomic status. We are a rapidly growing school district due to our close location to the Des Moines metro area. Plans are also underway to add more student classrooms by the 2021-22 school year.

The high school students involved in this study were all enrolled in a required physical science class. Of the 50 students in the experimental group, 40 were freshman and 10 were sophomores. Of the 48 students in the control group, 35 were freshman, 9 were sophomores, 3 were juniors, and 1 was a senior. The majority of high school science students take this as their opening course for our science pathway. This physical science course contains five physics based units and five earth science based units. The action research described in this paper was done during the physics portion of the curriculum in a “work, power, and energy” unit.

I have taught secondary science for eight years. Due to the small nature of Iowa schools I have taught very wide range of grade levels as well as a wide range of science courses. I have taught a version of this physical science class for three years now.

The main focus question for my action research was, *How does project-based learning influence student engagement and achievement?* I have chosen this focus question for my action research because my eight years of teaching observations in the science classroom have shown that some students are not motivated or engaged even during project-based learning activities. Lack of interest is a major frustration for me as I see project-based learning activities as real-life learning examples that should catch student interests and lead to high levels of student engagement. This action research should provide me with the reasons behind my students' engagement or lack of engagement in my project-based learning (PBL) activities, potentially enabling me to adjust lessons accordingly in order to reach more students. Student engagement may increase student achievement in time.

Sub-questions for me also included: *1) How does PBL influence student engagement? 2) How does PBL influence student achievement? 3)What factors of project-based learning appeal to students?*

This research has the potential to have a huge impact on the science department at my school district and possibly other core areas that engage in PBL. Some methods of data collection that will be described include: pretests, formative assessments, summative assessments, video-archived lessons, student focus group interviews, and Likert surveys. I have established a balance between quantitative data and well-detailed unbiased qualitative data.

CONCEPTUAL FRAMEWORK

Project-based learning is not a new strategy to the education world. For the past eight years I have used project-based learning strategies sporadically throughout my lessons. For my action research I wanted to explore existing studies on project-based work in order to mold my data collection methods. Research has shown that students who make real-life connections to curriculum are more likely to be engaged in the actual learning and not just concerned with "getting a grade" (Calore, 2018).

While my research will be conducted in an Iowa high school, recently it was noted that Oregon's state common core is to be designed to teach, "21st century skills for 21st century jobs." Oregon's common core is meant to go deeper and prepare students for future jobs. College professors claim that the common core does not prepare students for college and that common core standards are not aligned with collegiate expectations (Beck, 2014).

In 2015 Iowa adopted the Next Generation Science Standards (NGSS). These standards are set up in a way that the science education community has never seen. There are not only standards, known as disciplinary core ideas, but there are also crosscutting concepts and science and engineering practices. The crosscutting concepts include broad concepts such as cause and effect or systems and models. These concepts are intended to be spiraled throughout the entire science curriculum. Science and engineering practices call for educators to engage students in planning, investigating, and developing related to real world science phenomena. Phenomena are the driving force for all three parts of the NGSS. Phenomena must be designed to catch students' attention and "must not be easily 'googled' by students for answers."

"Just as the draft NGSS calls for deeper understanding and the application of knowledge, PBL demands the same," (Miller, 2013). PBL can be used to strongly support all three dimensions of the NGSS. In correlation with NGSS, projects are no longer meant to be an add-on at the end of unit. Projects are now the context for the learning. (Miller, 2013). The NGSS calls for students to build upon and prerequisite knowledge from all aspects of science. PBL is "not just one encounter with the content per se, but multiple encounters," (Miller, 2013). When students have multiple encounters with the content they build a much deeper understanding for the content. This deep understanding is then communicated via PBL to their peers, teachers, and other outside audiences. The learning is authentic and meaningful to each and every student.

The closest connection between the NGSS and PBL lies with the science and engineering practices embedded in the NGSS. (Larmer, 2015). These practices include core PBL ideas: ask questions, develop models, carry out investigations, analyze data, and design solutions. (Larmer, 2015). Some of the disciplinary core ideas of NGSS even call for specific project-based learning. One example of this is HS-LS2-7 "Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity." (Larmer, 2015). This detailed example show the strong connection between PBL opportunities in the classroom and fulfillment of NGSS based science-teaching practices.

One very interesting connection to my action research lied in the idea that parents do not understand the new common core wording and therefore often become frustrated and do not help their kids with learning at home. The professors also mock the idea that common core claims to have "content discovery." They argue that content discovery is

not always appropriate, that students often need background knowledge in a topic. The final big idea from this chapter is that "the common core creates dronelike workers, when right now we need to be creating doers, thinkers, and innovators" (Beck, 2014, p. 96). Building a project-based learning classroom is not an easy task. One key point made is that project-based learning requires the teacher to "let go" of traditional teaching and some traditional classroom management strategies. Teachers must allow discussion and discovery amongst students and their peers (Nelson, 2016). Students must find the tasks authentic, students must have freedoms for their learning paths, and students must see the teacher as a mentor not as a guide (Flowers, 2015). When building a project-based learning classroom the most important factor is the teacher. The most effective teachers do not always have the best test scores. This means that a project-based learning environment may not always translate to higher test scores for students.

Ravitch (2014) describes that reformers drive change and they use statistics like, "a highly effective teacher has three times the amount of learning occurring in their room as a hapless ineffective teacher." A USC professor, Michelle Rhee also states, "a poor minority student undergoes a change in life trajectory if they have three highly effective teachers in a row"(Ravitch, 2014). The author does counter some of these statements by saying that the majority of people who say a teacher changed their life often remember an unusually inspiring style of teaching, not that the teacher improved their standardized test score (Ravitch, 2014). "An unusually inspiring style of teaching" sounds like a project-based learning environment!

Project-based learning happens in the classroom and can be extended at home. Teachers must foster open-ended extended learning, which is spot on for

engagement in project-based learning. One of the only times homework is appropriate according to Alfie Kohn is when students are doing further research and inquiry on their own. This is due to the fact that they are already intrinsically motivated on the topic. Students must have choice in learning; free reading opportunities, and family homework. "Family" homework takes place when a family can log an activity they do in order for the student to share their experience back at school (Kohn, 2007). Choice is a large component of project-based learning. Student groups can set their own deadlines and hold themselves accountable; if work is needed outside of class time, they decide. Students must be so excited about a topic or project that they continue to work on it outside of school hours (Kohn, 2007).

Project-based learning is not an end-of-unit activity or a supplemental activity, it is the entire curriculum (Jones, 2016). Teachers must be all-in for project-based learning to be effective. Jones'data collection methods included: pre-tests and post-tests, student surveys, and student interviews (Jones, 2016). Jones concluded that PBL doesn't always increase student learning for a topic, but it does increase student engagement and interests. Students also gain real-life experiences that lead them to future careers (Jones, 2016).

A project-based classroom looks very different from a traditional classroom. Students cannot view their teacher as their only resource. This thinking must be shifted in order for students to take ownership of their learning and therefore become more intrinsically motivated to learn. Student choice and voice is a major factor in increasing student engagement with project-based learning (English, 2012).

The future jobs for our students will be challenging, and ever changing. Project-based learning prepares students for real-world applications much more than traditional lectures and direct instruction. Research shows that vast amounts of employers state that applicants have technical skills but lack communication, decision-making, and problem-solving skills (Youki, 2018). General strategies that can be used in project-based learning to increase student engagement include: comparing content to relevant situations, participating in discussions, and having students describe ideas in their own words (Youki, 2018).

Assessing PBL can be a challenge for teachers. Students often become frustrated with "team" grades. One idea to ensure equality in workload is to rotate students' roles from project to project. Students can shift from lead roles to secondary roles (Piper, 2012). Students can also be graded on specific individual skills throughout the school year. Some examples of those include: oral communication, written communication, role fulfillment, and leadership (Piper, 2012). Students are aware of the enjoyment and deeper learning behind PBL (Piper, 2012). Teachers must be willing to step outside of their own comfort zones alongside their students to make viable PBL experiences in their classroom.

A wide variety of information and resources can be found in relation to project-based learning and teaching techniques related to PBL. I have seen many examples of why project-based learning is a positive experience for students, and why many other traditional forms of teaching are negative experiences for students. I have gained great examples of data collection and am excited to share what my data helped me discover about the students' engagement and achievement in relation to project-based learning.

METHODOLOGY

Introduction

My research was conducted in order to determine if project-based learning influences student engagement and student achievement. My first sub-question of "How does PBL influence student engagement?" was measured through student observations, Likert surveys, and focus group interviews. This sub-question was the driving force behind my desire to catch all students' interests in each and every lesson.

My second sub-question of "How does PBL influence student achievement?" was measured mainly through student assessment data. The use of a pre-test, multiple formative assessments, and a summative assessment allowed me to gauge where students were achieving at specific points throughout the unit.

My final sub-questions ask, "What factors of project-based learning appeal to students?" This question has value in my teaching for years to come. I must discover what triggers student attention and what does not.

Treatment

The research was conducted in a freshman level physical science classroom. The unit being covered was "Work, Power, and Energy" and the unit lasted approximately 17 school days. Data was gathered from six class sections. Three of those class sections were used as an experimental group (n=50). Three of those class sections were used as a control group (n=48). The control group received the work, power, and energy unit as they would have prior to my project based learning research. Their unit had the basic setup of: lecture notes, activities, quiz, group project, and assessment.

The experimental group received a unit integrated with a variety of PBL activities and strategies. A specific example relates to a pendulum lab. Traditionally students would perform a "cookbook" lab with detailed step-by-step instructions to measure the potential energy of a pendulum. For my project-based learners there were no instructions, only a prompt. How much potential energy is needed to crack an egg? Students then designed a lab, built a pendulum, and tediously tested their pendulums to find the minimum amount of potential energy needed to crack an egg. Students faced frustration, disappointment, teamwork issues, and some even gave up at times. By the end of the lab, they had a very clear understanding of how potential energy was calculated and had built a strong series of connections related to the physics associated with a pendulum's design. Other strategies throughout the unit ranged from inquiry-based learning, student choice, and many other student-driven learning activities.

Study Population

All of the students in this study are enrolled in physical science as a required class. They did not elect to take the class. Students' ages range from 14-17 years old with the majority of students being 14. All of the students in this study have had vey little exposure to PBL. Some of their past teachers may have had projects included in their curriculum but it was not truly PBL. These students see projects as a fun add on at the end of a unit. In previous physical science units in the current school year students have learning that projects can now be the way they actually learn. They have also discovered that project can be used to assess their knowledge of specific NGSS skills. However this action research exposed the experimental group to full PBL implementation.

Both the behavioral plans and individualized education programs (IEPs) for the control group and experimental group are very low. The total for both is less than 4%. North Polk High School is not on standards based grading so this does offer a challenging hurdle for PBL. Project standards must be manufactured into assessment questions and scored on a rubric to reflect student achievement. (Appendix C)

Data Collection Methods

Table 1
Data Triangulation Matrix

Research Matrix:
How does project-based learning influence student engagement and achievement?

	Data Collection Method 1	Data Collection Method 2	Data Collection Method 3
Research SQ 1: How does PBL influence student engagement?	Student Engagement Observations	Likert Survey	Student Interviews (Focus Group)
Research SQ 2: How does PBL influence student achievement?	Quantitative Assessment Comparisons	Student Interviews	Video Data
Research SQ 3: What factors of project-based learning appeal to students?	Likert Scale survey for preferences	Student Interviews (Focus Group)	Student Engagement Observations

Throughout this action research a variety of data collection methods were used (Table 1). The most impactful methods included formative and summative assessments, student focus groups, and Likert scale survey data. Quantitative data gathered throughout the unit included: pretest, formative assessments, summative assessments, and student Likert survey responses. The control group and experimental group all received the same assessments and Likert surveys. Likert surveys were given at the conclusion of the unit. Most of this quantitative data was gathered using Google Forms and Google Sheets. The summative assessment did include free response questions that were graded based on a rubric. (Appendix C) The assessment results are represents with boxplots to show student growth throughout the unit. The boxplots also indicate a smaller achievement gap in the experimental group. (Figures 1-4)

Halfway through the unit all six class sections were asked a series of questions during a focus group session. All focus group sessions were audio recorded and student responses were sorted according to specific categories. Key quotations from these focus group sessions as well as overarching themes are noted in the data and analysis section. Detailed student observations related to student engagement were tracked throughout specific student activities. A Google spreadsheet (Appendix J) was used by a teacher assistant to mark engaged and disengaged student numbers. The information from this spreadsheet is mentioned in the data and analysis section.

Likert surveys were given to the students following their unit summative assessment. Questions were mainly based on their interests in project-based learning opportunities, and their reasoning behind their level engagement in a science specific learning environment. These results are displayed in figures 5-6.

Video data was gathered during assessment level lab activities to ensure that student achievement could be observed in the form of student-student interactions and communication. This video data was used to clarify on several other forms of data collection. For example, the number of engaged versus disengaged students.

In conclusion, all of the data collection methods noted in the *Data Triangulation Matrix* (Table 1) were effective in displaying the entire student engagement and achievement picture. The most effective data collection methods included formative and summative assessments, student focus groups, and Likert scale survey data. Specific subgroups of students preferred to have voice in Likert surveys, while others enjoyed the focus group sessions. The variety of methods allowed me to see the true data associated with each student.

DATA AND ANALYSIS

The first data analyzed was the pretest and formative assessments. This data was used in real-time to influence any instructional changes needed. For example towards the end of the unit an optional "math and equations" station was offered to students still struggling with work, power, and energy equations. Focus question data was then organized followed by video reviews and finally the collection of Likert survey data. Likert survey data was discussed with students following the unit. This discussion helped bring the big picture together for the unit as a whole.

In regards to subquestion two, *How does PBL influence student achievement*? Both the control group and experimental groups began the unit with a pre-test. The boxplot below displays the initial starting point for all students in the unit

(Figure 1). The pre-test results show that students in both groups clearly lack knowledge in work, power, and energy concepts.

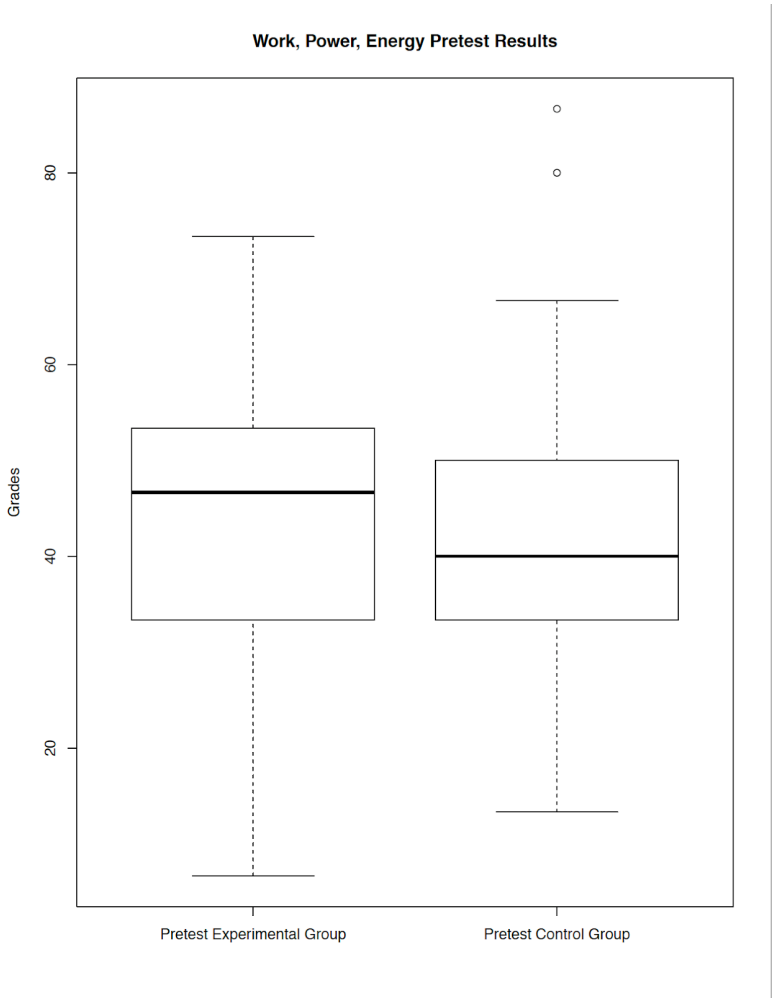


Figure 1. Pre-test score distributions of the experimental group (*N*=50) and the control group, (*N*=48).

Following the pre-test the control group completed a note-taking activity, sample problems practice, and an inclined plane lab described in the textbook. Control group students were then given formative assessment #1. (Appendix H) Students in the experimental group were given choice on a class presentation. Students were able to choose their media avenue and their content related topic. Students were then able to view peer presentations of their choosing to gain access to vocabulary and math related

content. (Appendix G) Students also did sample problems on their own. A small group session was also offered for any students still struggling with math related calculations. Experimental group students were then given formative assessment #1. (Appendix H)

The boxplot below shows the results of formative assessment #1 for both the control group and the experimental group (Figure 2). The mean score for the control group was 57.48% while the mean score for the experimental group was 58%. The boxplots also show nearly identical results, which means that up to this point in the unit the project-based learning approach had shown little to no effect on student achievement.

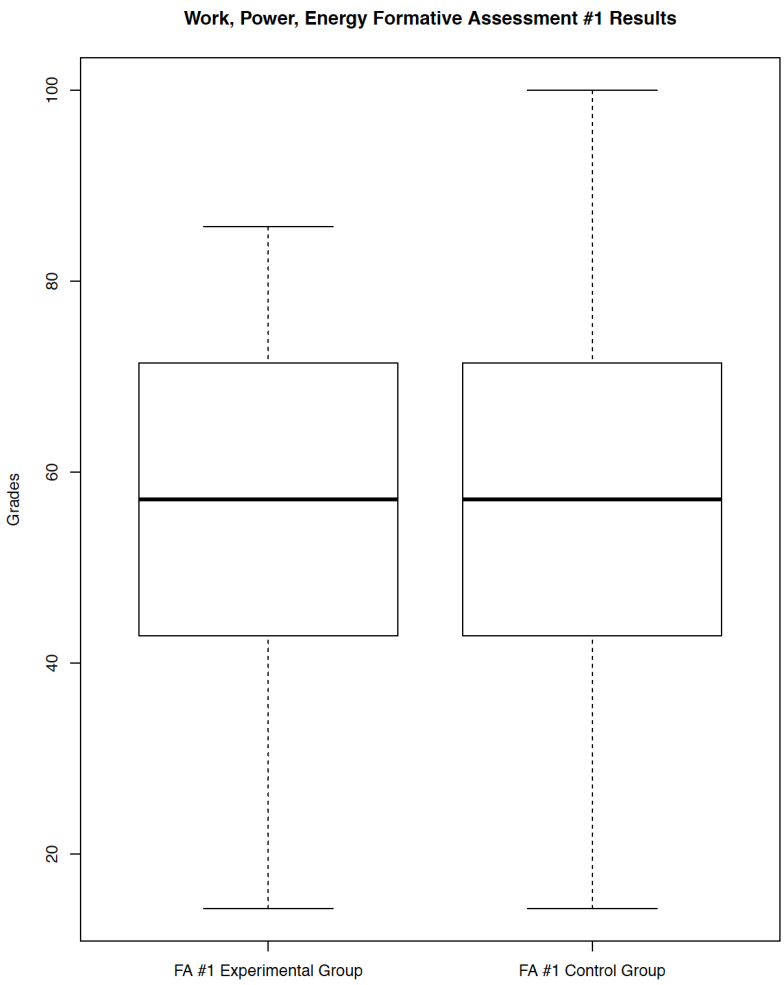


Figure 2. Formative Assessment #1 score distributions of the experimental group (*N*=50) and the control group, (*N*=48).

Following formative assessment #1 students in the control group compared kinetic energy and potential energy using lists, created their own video demonstrations, read an article on roller coaster physics, and manipulated roller coaster simulations. The control group students were then given formative assessment #2. (Appendix I) Students in the experimental group conducted their own mechanical advantage lab, created kinetic energy and potential energy video demonstrations, and designed their own pendulum lab to determine the potential energy needed to crack an egg. The experimental group

students were then given formative assessment #2. The boxplots below (Figure 3) show that while both groups have identical median scores, the control group has substantially improved the majority of its students' scores, while the experimental group has a wide range of assessment scores below the mean score.

The average normalized gain for the control group between formative assessment 1 and formative assessment 2 was 56.96%. The average normalized gain for the experimental group between formative assessment 1 and formative assessment 2 was 50%. Both of these results show vast student increase in achievement. The control group is actually achieving at a higher level at this point in the unit than the experimental group.

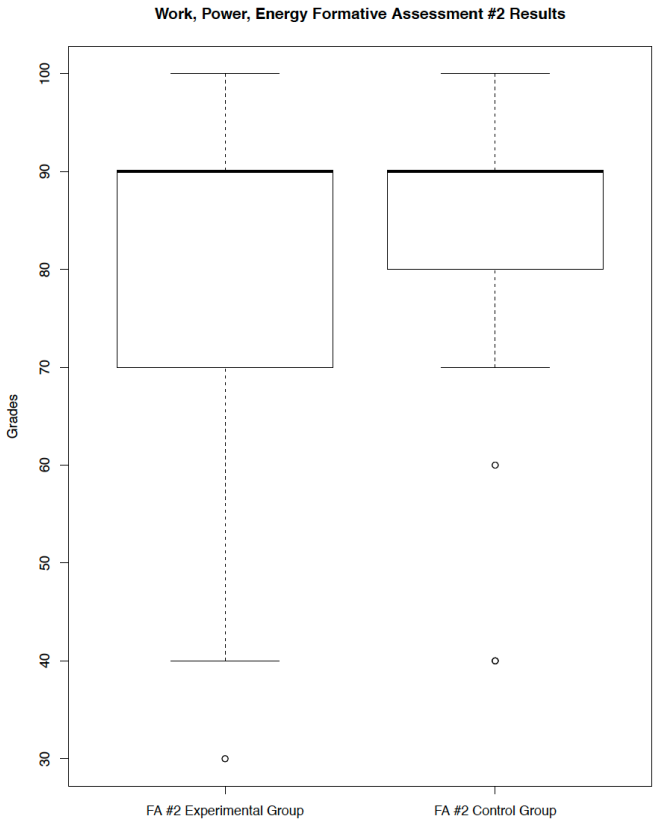


Figure 3. Formative Assessment #2 score distributions of the experimental group (*N*=50) and the control group, (*N*=48).

Following formative assessment #2 the students in the control group conducted a step by step pendulum lab, were assigned groups and roles for a Rube Goldberg project, built a successful Rube Goldberg machine, completed a unit study guide, and participated in a classroom review game. Control group students were then given the summative assessment. Experimental group students completed several roller coaster simulations, were assigned groups and roles for a Rube Goldberg project, built a successful Rube Goldberg machine, completed a unit study guide, and participated in a partner oriented unit review game. Experimental group students were then given the summative assessment. The boxplots below (Figure 4) show that the median score for the control group was higher (87.5%) than the experimental group (82.5%). However the boxplots also indicate that more students scored in the proficient range in the experimental group than did in the control group. The Interquartile range (IQR) for the experimental group was 7.5 (18.75%) while the IQR for the control group was 12.5 (31.25%). This means that in the experimental group the majority of the students scored in the range of 73.75% to 92.50%. In the control group the majority of students scored in the range of 63.75% to 95.00%. This wide range of scores in the control group indicates major inconsistencies in student learning. There were still high achieving students in the control group but they were larger numbers of below proficiency students.

The average normalized gain for the control group from formative assessment 2 to the summative assessment was -10.92%. The average normalized gain for the experimental group from formative assessment 2 to the summative assessment was

15.95%. We now see that by the end of the unit the experimental group students have "leap frogged" the control group in means of achievement. Students in the control group showed higher achievement at the earlier stages of the unit but by the time the summative assessment was administered the control group students had plateaued and possibly lost some learning from the start of the unit. Experimental group students continued to learn throughout the entire unit and displayed peak achievement for the summative assessment.

The number of students to score over 80% on the summative assessment in the control group was 31 out of 48 [64.6%]. In the experimental group 33 out of 50 [66%]. This may seem like only a slight increase, but this along with the smaller range of scores shows that more students in the experimental group were able to display proficiency on the summative assessment.

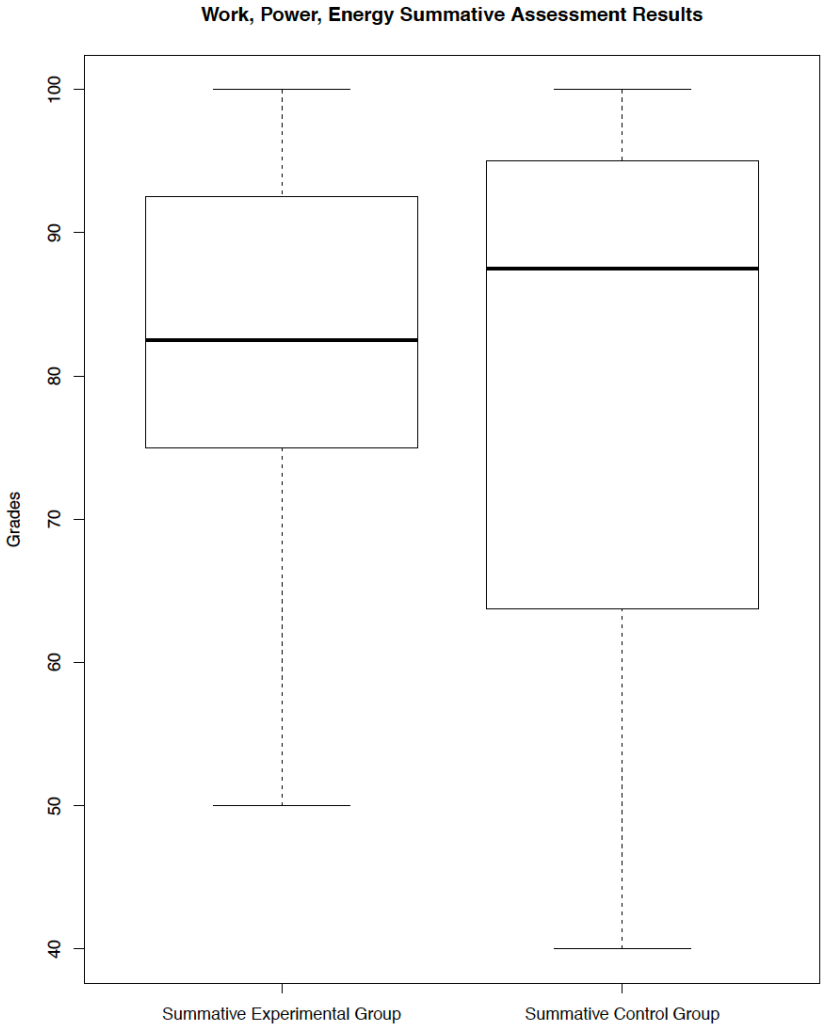


Figure 4. Summative Assessment score distributions of the experimental group (*N*=54) and the control group, (*N*=48).

Student interviews in the form of small focus groups were used to address all three sub-questions. Focus groups consisted of 10 students from the experimental group and 10 students from the control group. These group sizes often lead to the most meaningful discussions. Students are not overwhelmed like a class discussion and are willing to share their specific thoughts.

I began focus group sessions by focusing on sub-question #1, *How does PBL influence student engagement?* I asked students, "Are you more engaged when the teacher is speaking or when working with peers. Both the control group and experimental group unanimously responded, "peers." I also asked the students, "What does an engaged student look like?" Common responses included: "involved, problem solving, participation, eye contact." I also asked what a disengaged student looks like and most responses were simply the opposite of the engaged students responses. When asked, "What causes a student to be disengaged?" several students had notable remarks. Some included, "boredom," "distractions," "the teacher," and "tired." One student even stated, "When students are disengaged that's the teacher's fault, they need to make it interesting!" A follow up question of mine was "How do teachers respond if you appear bored or disinterested?" Student responses included, "they yell at us," or "they just keep talking and let us sit there."

I then asked the focus groups to agree upon a percentage for the amount of time they are truly engaged in class throughout the school day. The majority of female students responded that they were engaged about 80% of the time. One student stated, "I am engaged 80-90% of the time if I like the class." The male student answers ranged from 40% to 60% of the time. The student's reasoning for these answers, "I don't care," "I don't like school," "I get distracted easily."

For sub-question #3, "*What factors of project based learning appeal to students?"* the best data was collected via Likert Scale survey and through student engagement observations. For the student engagement observations I was fortunate enough to have a student aid in the classroom to fill out a spreadsheet that I designed to show the number

of engaged students versus disengaged students throughout an entire class period. Every five minutes my student aid noted the number of engaged students, disengaged students, the current classroom activity, and the actions of the disengaged students. I am aware that this is a very subjective exercise but I did have the fortune of a very blunt student aid. He noted every detail, especially if I was late to class! I am confident that these observations do depict what happens in my classroom. I also have watched several video recordings of my class as a reference to these observations.

After one week of these detailed observations it was very clear that students were very rarely engaged an entire class period. The most common times for students to display engagement correlated to times when they were interested, or working on a project with a small group. The only class period of the week in which it was noted that all students were engaged throughout the entire 46 minutes was the climactic end to our Rube Goldberg projects. Student choice led to student interest, which then led to higher numbers of engaged students. The most common actions of disengaged students included: talking, heads down, and off task actions. Disengaged students often spread like wildfire in a classroom. Some of the most vital students to keep engaged are the initial students that teeter on the edge of engagement at the beginning of class. Many of my data points showed that once a student was labeled "disengaged" they rarely showed engagement for the remainder of the class period.

A Likert Scale survey was also given to students pertaining to the appeal of PBL. *Figure 5* below displays the control group student responses at the conclusion of the unit. *Figure 6* below shows experimental group student responses at the conclusion of the unit. You can see that these stacked bar charts indicate the majority of students

agree with the statements provided. Students enjoy real-life project-based learning opportunities, choice throughout projects, and students feel they learn more in classes they enjoy. Results were very similar amongst the control group and experimental group.

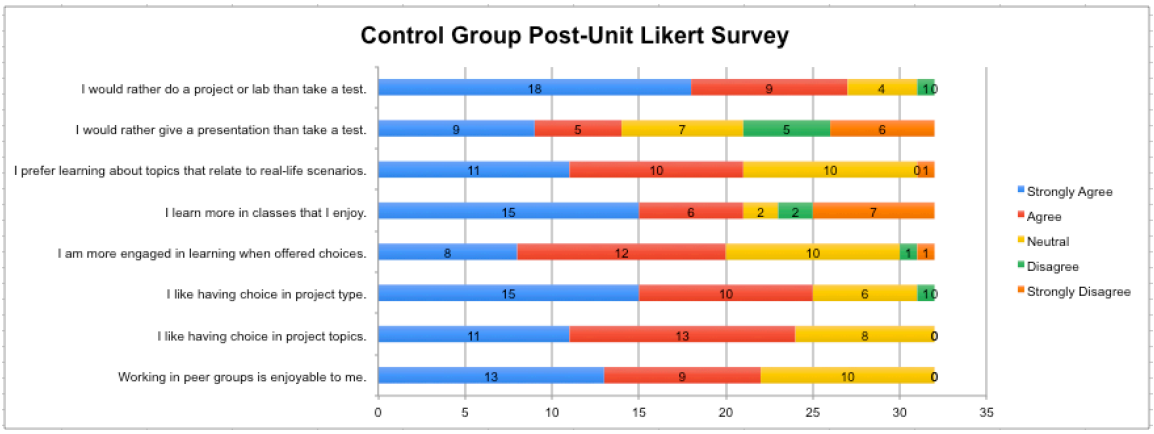


Figure 5. This stacked bar chart displays control group student survey responses to questions regarding project-based learning and specific learning opportunities in the classroom.

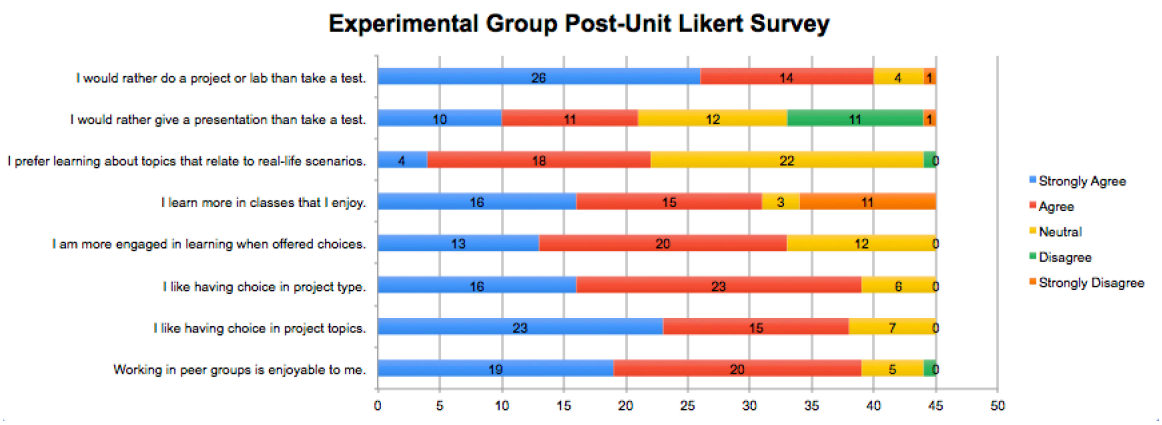


Figure 6. This stacked bar chart displays experimental group student survey responses to questions regarding project-based learning and specific learning opportunities in the classroom.

The first key finding from my data was the fact that experimental group students took more time in the unit to begin displaying proficiency on formative assessments. The summative assessment showed that the experimental group of students had a smaller

achievement gap with more students around the proficiency range. The control group still had high achieving students, but also had more low scoring students than the experimental group. Focus group results showed through blatant student honesty that students are bored at school and disengaged. Students are well aware of what helps engage them in content and what does not. Likert survey results showed that students enjoy many factors of PBL that can lead to higher levels of student engagement. These factors include: student choice, enjoyment, real-life connections and working in peer groups.

INTERPRETATION AND CONCLUSION

The purpose of this action research project was to determine the influence that PBL can have on student engagement and student achievement. Through the use of multiple assessments, Likert surveys, focus group interviews, and student observations it was clear that project-based learning creates higher levels of student engagement and achievement. The PBL taught experimental group showed higher numbers of students scoring in the proficiency range [EG 66% were above 80%, CG 64.6% were above 80%]. The experimental group also showed a level playing field for student achievement. The majority of students scored between 73.75% and 92.50%. The control group had a much wider range of student achievement [63.75-95.00%], which indicated that several students had been "left behind." Consequently, an achievement gap had been created in the control group.

Assessment data from my action research showed that students exposed to PBL may take more class minutes to display learning and achievement, but by the unit's end these students display higher levels of achievement. This is evident in comparing my

formative assessment data to my summative assessment data. The PBL classroom also demonstrates a much smaller gap in achievement than the control group did. In the control group "high flyers" still achieved at high levels while the rest of the students were left behind. PBL offered the experimental group a variety of ways to learn via student choice, peer help, and basic joy in learning.

The experimental group likely lagged behind in early unit achievement because they had not been exposed to as much content as the control group. The experimental group was diving deeper while the control group was brushing the surface. Students in the control group that can easily memorize information with very little deep understanding were able to display proficiency on the formative assessment as their were no free response questions to elicit deep learning.

In a PBL classroom, students must find the tasks authentic, students must have freedoms for their learning paths, and students must see the teacher as a mentor not as a guide (Flowers, 2015). Throughout my work, power, and energy unit the students in the experimental group were able to exercise choice in their learning, collaborate with peers, and reflect on what they had or had not mastered in the learning.

Focus group responses indicated that students clearly understand the differences between engaged students and disengaged students. One student stated, "Engaged students are always asking lots of questions, while disengaged students just don't care." Students also voiced that the main cause of their disengagement is most often boredom. Research has shown that students who make real-life connections to curriculum are more likely to be engaged in the actual learning and not just concerned with "getting a grade" (Calore, 2018). Classes must connect to students and spark their joy for

learning. PBL opens up the curriculum in ways that the students respond to. Students take ownership in their learning, which in turn creates higher levels of student engagement and achievement in a much more enjoyable classroom setting.

Likert surveys administered to students indicated that the majority of students feel that they learn more in a class they enjoy, and in classes that offer student choice in topics and project completion (67.5%). Likert surveys also showed that students enjoy working in peer groups and most prefer this to direct teacher instruction or lectures (67.5%).

VALUE

All science students should get the opportunity to learn in a PBL classroom. PBL classrooms offer real-life connections to content. Research has shown that students who make real-life connections to curriculum are more likely to be engaged in the actual learning and not just concerned with "getting a grade" (Calore, 2018). Students should be able to create their own learning experiences through inquiry-based learning in a PBL classroom. It has been argued by many workplace managers and owners that, "the common core creates dronelike workers, when right now we need to be creating doers, thinkers, and innovators." (Beck, 2014). My action research data urges teachers to create a classroom of doers, thinkers, and innovators through project-based learning.

It is with confidence that I can say that students who are enjoying learning will be more engaged. This was indicated in my Likert survey data. PBL can be specifically crafted for student enjoyment, and therefore student engagement. STEM education and STEM related work fields call for high levels of problem solving and teamwork. PBL can provide that framework for many students seeking a STEM career. Higher levels of

student engagement inevitably lead to higher levels of student achievement as shown in my summative assessment results.

It is not easy for teachers to “let go” of their classrooms, so they must be provided with training and support from local administration. A PBL classroom must have a sense of controlled chaos amongst the teacher and the students. Teachers must allow discussion and discovery amongst students and their peers (Nelson, 2016). Students must find the tasks authentic, students must have freedoms for their learning paths, and students must see the teacher as a mentor not as a guide (Flowers, 2015).

It really felt like the experimental group enjoyed the unit much more than the control group. At one point I even felt sincere empathy for the control group as some students asked why their unit was going differently than the other class periods. Experimental group students showed more curiosity and initiative while control group students were just trying to “get through it.”

Low achieving students struggled in the traditional control group. These students don't always respond to my style of teaching and when they have no peer interactions to rely on they drop below proficiency. In the experimental group, low achieving students had more of a spark to their work ethic. They enjoyed working with peers to find new ways of learning that were much more useful to them than my direct instruction.

High achieving students in the experimental group were annoyed at times. They are good at “traditional” school and saw project-based learning as a threat to their grade at first. In time they realized that actual learning was more enjoyable than grade hunting. High achieving students in the control group were able to remain confortable due to their ability to be good “traditional” school. However high achieving students in the control

groups did not help any of their peers and did not improve any communication or leadership skills.

In doing this action research I had several realizations as a science teacher. The PBL I thought I had been doing in previous years wasn't truly PBL. I have a lot of work to do to create units with ongoing and meaningful PBL as I move forward. As I move forward I plan to gather student feedback much more often on specific projects, assessments, and units. Student feedback not only helps my future implementation of lessons, but also provides an opportunity for student metacognition. I will also take pride in allowing my classroom to have some controlled chaos. A culture must be set at the beginning of the school year for high levels of student collaboration, enjoyment, engagement, and achievement.

A change I would need to make the next time I conduct similar research is my overall organization of student data. I did well organizing a unit for my research to be conducted, but struggled after collecting all of my data. Now that I have a better idea of how this process works I will be able to better envision which statistical analysis tests should be conducted and referenced.

PBL may require more time in the classroom for students to reach high levels of achievement. This extended time and real-life connections leads to higher levels of student engagement and achievement by the end of a unit. Meaningful PBL experiences that actively engage students can inspire them to pursue STEM related careers. Students will remember exciting projects that involved student choice, peer involvement, and even frustrations along the way. Students will not remember worksheet 42A.

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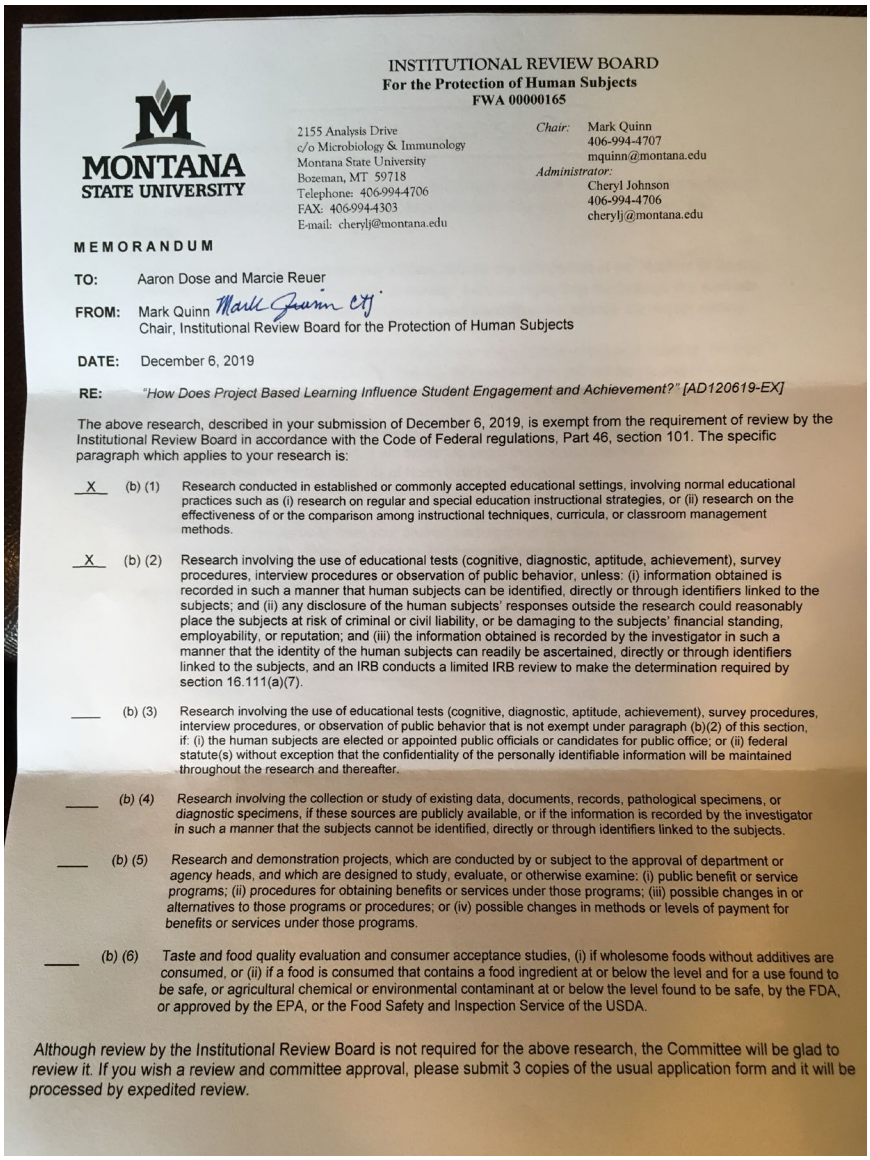
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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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Cheryl Johnson
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MEMORANDUM

TO: Aaron Dose and Marcie Reuer

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

DATE: December 6, 2019

RE: *"How Does Project Based Learning Influence Student Engagement and Achievement?" [AD120619-EX]*

The above research, described in your submission of December 6, 2019, 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; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

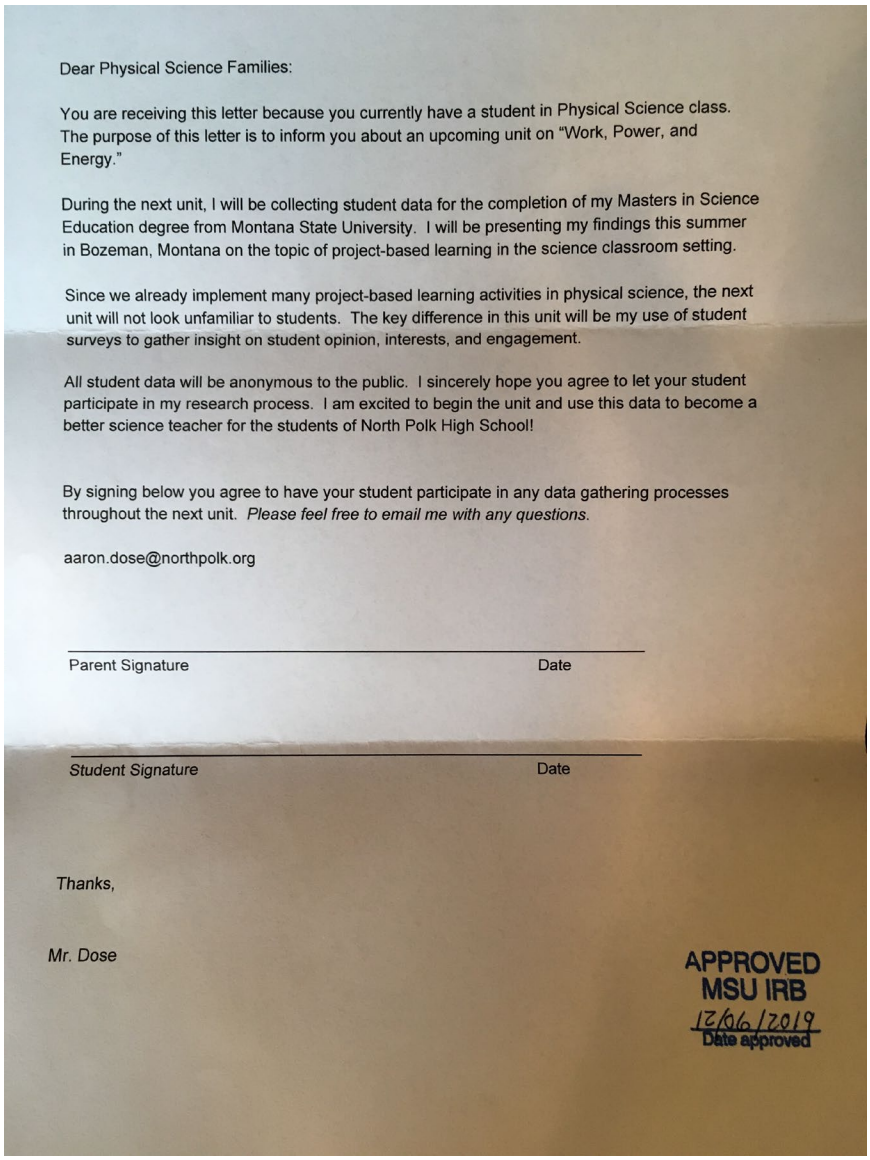
____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public 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.



Dear Physical Science Families:

You are receiving this letter because you currently have a student in Physical Science class. The purpose of this letter is to inform you about an upcoming unit on "Work, Power, and Energy."

During the next unit, I will be collecting student data for the completion of my Masters in Science Education degree from Montana State University. I will be presenting my findings this summer in Bozeman, Montana on the topic of project-based learning in the science classroom setting.

Since we already implement many project-based learning activities in physical science, the next unit will not look unfamiliar to students. The key difference in this unit will be my use of student surveys to gather insight on student opinion, interests, and engagement.

All student data will be anonymous to the public. I sincerely hope you agree to let your student participate in my research process. I am excited to begin the unit and use this data to become a better science teacher for the students of North Polk High School!

By signing below you agree to have your student participate in any data gathering processes throughout the next unit. *Please feel free to email me with any questions.*

aaron.dose@northpolk.org

Parent Signature Date

Student Signature Date

Thanks,

Mr. Dose

APPROVED
MSU IRB
12/06/2019
Date approved

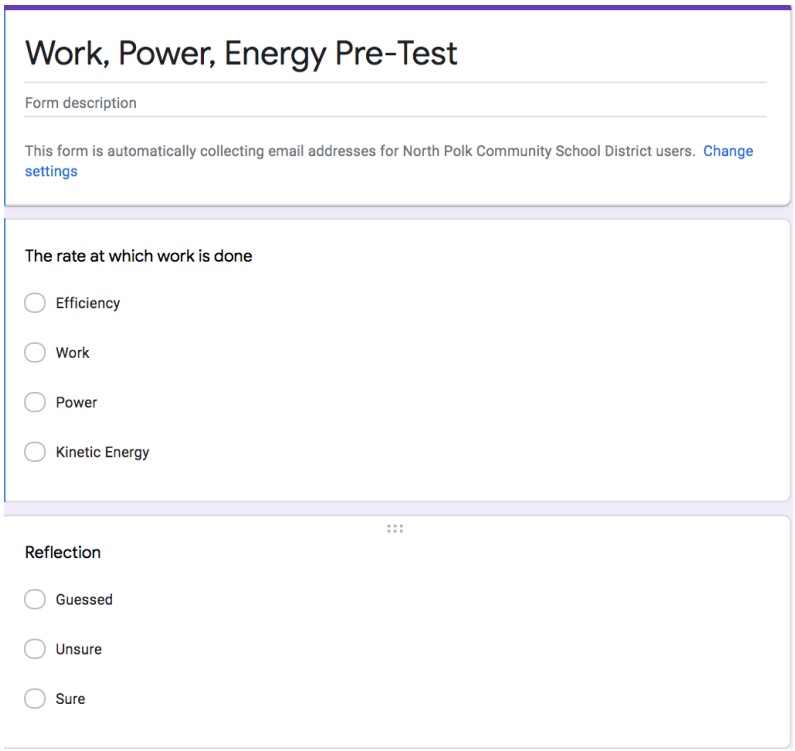
APPENDIX B

WORK, POWER, AND ENERGY

QUESTION PROMPTS USED IN

PRE-TEST

AND SUMMATIVE ASSESSMENT



Work, Power, Energy Pre-Test

Form description

This form is automatically collecting email addresses for North Polk Community School District users. Change settings

The rate at which work is done

- Efficiency
- Work
- Power
- Kinetic Energy

Reflection

- Guessed
- Unsure
- Sure

Compares the work input to the work output 1 point

- ◯ efficiency
- ◯ mechanical advantage
- ◯ potential energy
- ◯ power

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

Energy of objects in motion 1 point

- ◯ kinetic energy
- ◯ potential energy
- ◯ force
- ◯ efficiency

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

Force exerted over a distance 1 point

- ◯ Work
- ◯ Power
- ◯ Energy
- ◯ Force

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

When kinetic energy and potential before an action are the same as kinetic energy and potential energy after an action. This shows... 1 point

- ◯ Efficiency
- ◯ Mechanical Advantage
- ◯ Work Input
- ◯ Law of Conservation of Energy

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

Stored energy or energy due to position 1 point

- ◯ Kinetic energy
- ◯ Projectile energy
- ◯ Potential energy
- ◯ work

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

Which of the following would increase the mechanical advantage of a ramp? 1 point

- ◯ Adding resistance
- ◯ increasing the distance of the ramp
- ◯ increasing friction
- ◯ increasing the mass of the object being moved

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

Which of the following statements is true about the law of conservation of energy? 1 point

- ◯ Energy cannot be created
- ◯ Energy cannot be destroyed
- ◯ Energy can be converted to other forms
- ◯ All of the above

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

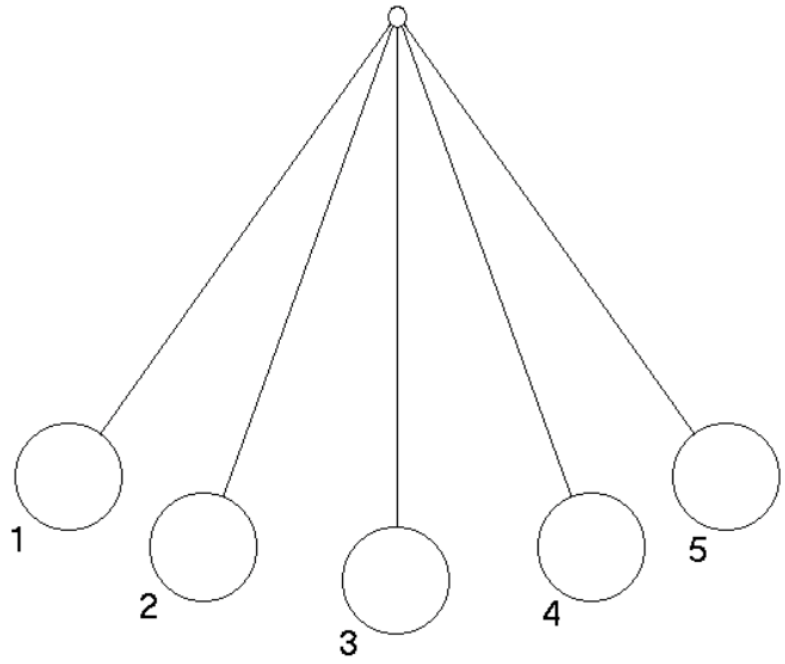
If someone does work very quickly they have a lot of: 1 point

- ◯ potential energy
- ◯ mechanical advantage
- ◯ power
- ◯ Newtons

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

Which stage of the pendulum swing has the most kinetic energy? 1 point

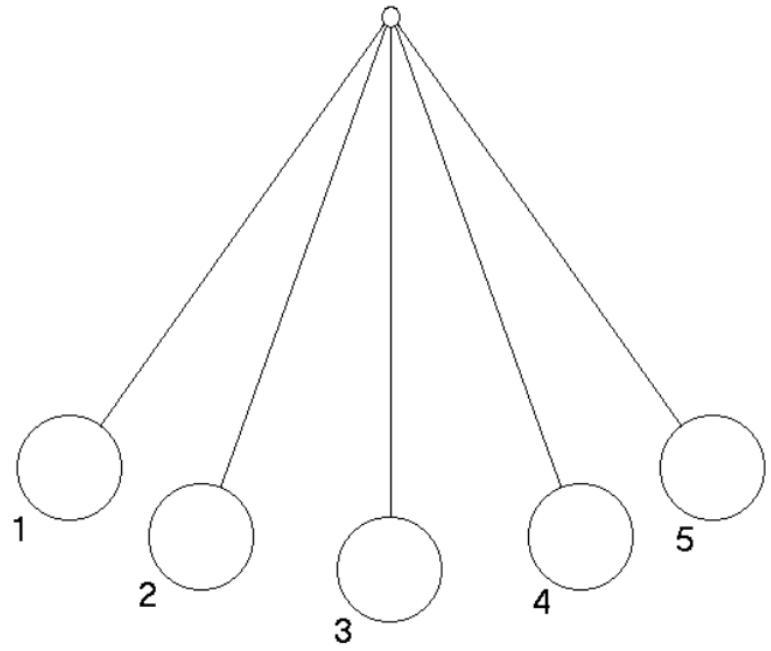


- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

Which stage of the pendulum swing has the most potential energy? 1 point



- ○ 2
- ○ 3
- ○ 4
- ○ 5

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

A baseball with a mass of 0.15 kg is traveling at a speed of 40 m/s. What is the baseball's kinetic energy from this motion? 1 point

- ◯ 6 Joules
- ◯ 120 Joules
- ◯ 100 Joules
- ◯ 12 Joules

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

It takes you 500 J of work to lift a piano onto the second floor of your home using a pulley system. Between the piano and friction, the work output is 300 J. What is the efficiency of the pulley system? 1 point

- ◯ 60%
- ◯ 600%
- ◯ 166%
- ◯ 30%

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

A baseball with a mass of 0.15 kg is traveling at a speed of 40 m/s. What is the baseball's kinetic energy from this motion? 1 point

- ◯ 6 Joules
- ◯ 120 Joules
- ◯ 100 Joules
- ◯ 12 Joules

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

It takes you 500 J of work to lift a piano onto the second floor of your home using a pulley system. Between the piano and friction, the work output is 300 J. What is the efficiency of the pulley system? 1 point

- ◯ 60%
- ◯ 600%
- ◯ 166%
- ◯ 30%

Reflection

- ◯ Guessed
- ◯ Unsure
- ◯ Sure

APPENDIX C

WORK, POWER, AND ENERGY

SUMMATIVE ASSESSMENT

FREE RESPONSE QUESTIONS

& SCORING RUBRICS

Work, Energy, Power Free Response Questions Name:_____

1. Draw two ramps. **(5 points)**

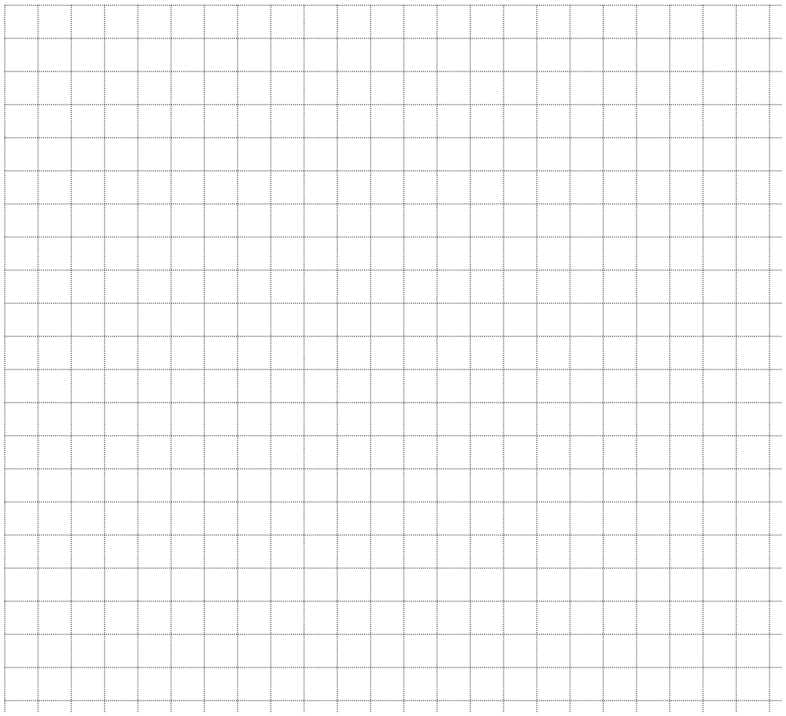
5	3	1
Drawing includes two ramps. One ramp must have a greater mechanical advantage than the other. Ramps must be labeled with ramp distance and ramp height. Ramp drawings also include labeled forces required to drag a mass up the ramp. Force required to lift the mass is noted near the ramp and mechanical advantage has been calculated.	Drawing includes two ramps. One ramp has a greater mechanical advantage than the other. Ramp heights and distances are labeled. Ramp forces are labeled but mechanical advantage calculations are incorrect.	Drawing includes two ramps. One ramp has a greater mechanical advantage than the other. Ramps are not clearly labeled and mechanical advantage has not been calculated.

2. Graphing Pendulum data. **(5 points)**

5	3	1
Gravitational Potential Energy has been calculated correctly for each stage of the pendulum and has been graphed in comparison to height. Graph is properly labeled.	Gravitational Potential Energy has been calculated correctly for each stage of the pendulum and has been graphed in comparison to height. Graph lacks proper labels.	Errors have been made in gravitational potential energy calculations. Graph lacks correct labels.

Mass of Pendulum = 1 Kg

Stage	Height in meters	GPE in Joules
1	0.5	
2	1.0	
3	1.5	
4	2.0	
5	2.5	
6	3.0	



3. Draw a Rube Goldberg machine. **(5 points)**

5	3	1
Drawing includes all six simple machines. All six simple machines are labeled. Rube Goldberg machine has a clear simple task to accomplish. Kinetic energy (KE) is correctly labeled in 3 locations. Potential energy locations is correctly labeled in 3 locations.	Drawing includes all six simple machines. Rube Goldberg has a clear simple task. Kinetic energy and potential energy labels are not entirely correct.	Drawing has 5 or fewer simple machines. Kinetic and potential energy locations are not label correctly.

4. Energy Transformation. **(5 points)**

5	3	1
Student explains how radiant energy be transformed several times to produce human motion and work. Must have multiple steps.	Student explains how radiant energy can be transformed but is missing several steps.	Student does not adequately explain radiant energy transformation.

APPENDIX D

PROJECT-BASED LEARNING

STUDENT LIKERT SURVEY

I am most engaged when working in peer groups.

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

I am most engaged when the teacher is lecturing.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

Working in peer groups is enjoyable to me.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

Working alone is enjoyable to me.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

I like having choice in project topics.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

I like having choice in which type of project I will complete over a specific topic.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

I am more engaged in learning when offered choices.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

I learn more in classes that I enjoy.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly agree

I prefer learning about topics that relate to real-life scenarios.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

I would rather give a presentation than take a test.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

I would rather do a project or lab than take a test.

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

My favorite part about the previous unit was:

Your answer

My least favorite part about the previous unit was:

Your answer

APPENDIX E

STUDENT FOCUS GROUP

INTERVIEW QUESTIONS

SQ#1: **How does PBL influence student engagement?**

Unit: Energy, Work, Power

Focus Group 1 Makeup: 10 students from class periods 6, 7, 8 (Control Group)
Focus Group 2 Makeup: 10 students from class periods 2, 3, 4 (Experimental Group)

Each focus group will consist of students with varying academic achievement levels.

BEFORE UNIT QUESTIONS:

Question 1:
Are you more engaged when the teacher is talking or when you are working with peers? Why?

Question 2:
Do you enjoy answering open-ended questions? Why?

Question 3:
Describe a time when you have been frustrated with a teacher for not giving you the answer to a question:

SQ1: How did you feel?
SQ2: Why do you think the teacher did this?

Question 4:
What is your favorite part of physical science class? Why?

Question 5:
Describe what an **engaged** student looks like in the classroom:

Question 6:
What type of classroom activities often lead to students being off task? Or what part of class?

SQ: What does an **off-task** student look like?

AFTER UNIT QUESTIONS:

Focus Group 1: CONTROL

Question 1:
What was your favorite part of the unit?

Question 2:
What part of the unit led to the most learning for you?

Question 3:
What is one part of the unit you would change? Why?

Question 4:
When were you frustrated during this unit? Did this lead to learning?

AFTER UNIT QUESTIONS:

Focus Group 2: EXPERIMENTAL

Question 1:
What was your favorite part of the unit?

Question 2:
What part of the unit led to the most learning for you?

Question 3:
What is one part of the unit you would change? Why?

Question 4:
Did you like having choice in projects during this unit?

Question 5:
When were you frustrated during this unit? Did this lead to learning?

APPENDIX F
RUBE GOLDBERG PROJECT ROLES

SIMPLE MACHINE: Period _____

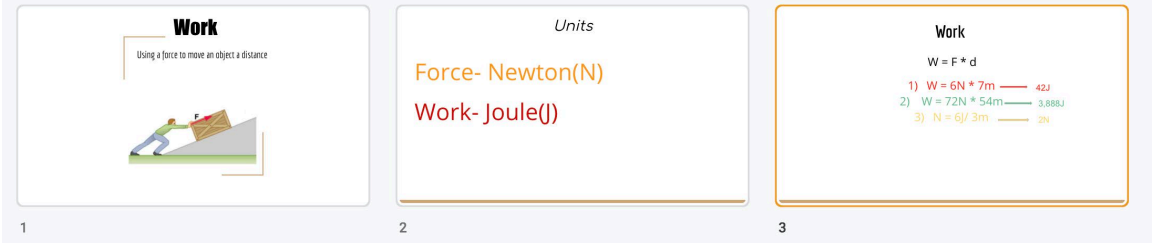
Student Name	Role	Role Description
	Communicator	Figure out how to mesh your simple machine with other simple machines in the class. Discuss location and materials needed to make transitions smooth. Must be in constant contact with other communicators.
	Architect	Major role in designing how simple machine will work. Has final say in design decisions. Must work closely to get input from all group members.
	Sketch Artist	Sketch simple machine. List materials you will need. Ensure machine will transition into yours well and that your machine can transition into the next machine.
	Materials Prepper	Guarantee that all materials needed will be available the day of the competition. You are not responsible for bringing all the materials. You are responsible for dividing up materials for group members to bring. The day of the build you help the architect build with the needed materials.

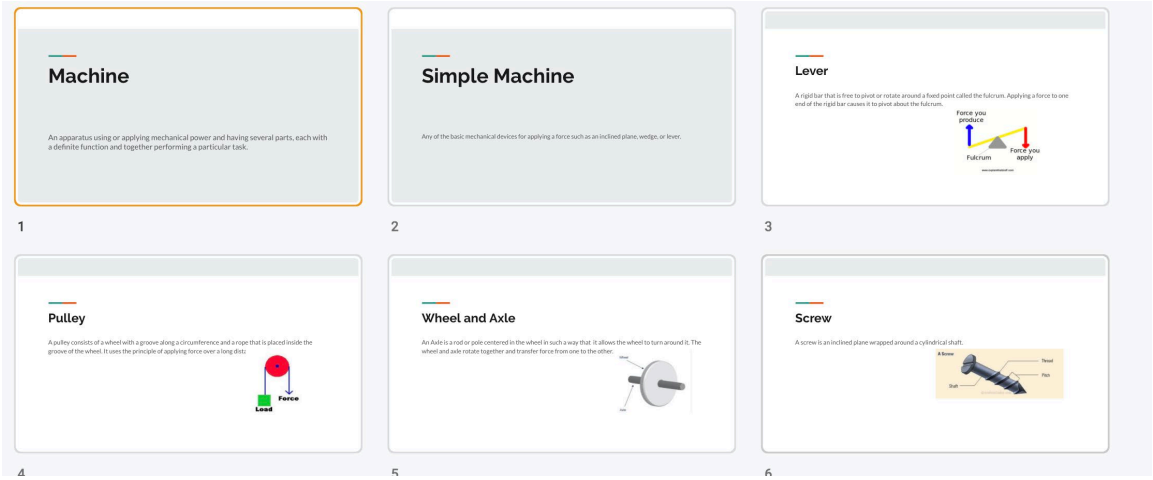
APPENDIX G

EXPERIMENTAL GROUP STUDENT PRESENTATION EXAMPLES

Choose your group # and the number of members you want in your group.
Choose to make a video, google slideshow, poster, skit, smore, canva, etc.)

Group #	Topics that need to be covered	Resources
1	Work, Equation for Work, unit for work, unit for force, create 3 work sample math problems Student Names Here Student Names Here Student Names Here	https://docs.google.com/presentation/d/1-j8vpk8ueWGamJZiQZkpTF1TLaBQg_Avv0e-Tgtz0sk/edit?usp=sharing https://docs.google.com/presentation/d/1bj6cow4HF7W91uhtotpP4JT86CtDe43eXKC4mtdqX7A/edit?usp=sharing
2	Define machine, define simple machine, list 6 types of simple machines, draw and explain six types of simple machines Student Names Here Student Names Here Student Names Here	https://drive.google.com/file/d/1aKBFf9p1E9Ea2vShFAvgAymHg6O6pGOy/view?usp=sharing https://drive.google.com/file/d/19dT2lFgotpbAuSKeougFJugCBNPW1Cqh/view?usp=sharing https://docs.google.com/presentation/d/1HbLHfylu74Fb15u92_kLbfOOxS5Yz7P9JD6iMiFzrVE/edit?usp=sharing https://drive.google.com/file/d/1Du2k9L_r23aNJ6_1dGHWgEWagfiLt6Zw/view?usp=sharing
3	Mechanical Advantage equation, create 3 mechanical advantage sample problems, What is efficiency equation, create 3 efficiency sample problems Student Names Here Student Names Here Student Names Here	https://docs.google.com/presentation/d/12s-er3ruEs6CXYxbpGAqL6GhSsIte7f9rGU8C4yNYGo/edit?usp=sharing https://docs.google.com/presentation/d/1tdEiQzPBsNiwaAEzkY0qrkqIlcmPn4WQzvTLIhObBdY/edit?usp=sharing https://docs.google.com/presentation/d/1x




Machine
An apparatus using or applying mechanical power and having several parts, each with a definite function and together performing a particular task.
1
Simple Machine
Any of the basic mechanical devices for applying a force such as an inclined plane, wedge, or lever.
2
Lever
A rigid bar that is free to pivot or rotate around a fixed point called the fulcrum. Applying a force to one end of the rigid bar causes it to pivot about the fulcrum.
Force you produce
Fulcrum
Force you apply
3
Pulley
A pulley consists of a wheel with a groove along a circumference and a rope that is placed inside the groove of the wheel. It uses the principle of applying force over a long dist.
Force
Load
4
Wheel and Axle
An Axle is a rod or pole centered in the wheel in such a way that it allows the wheel to turn around it. The wheel and axle rotate together and transfer force from one to the other.
5
Screw
A screw is an inclined plane wrapped around a cylindrical shaft.
Thread
Pitch
Shaft
6

APPENDIX H

FORMATIVE ASSESSMENT #1 QUESTIONS

WPE Formative Assessment #1

Form description

This form is automatically collecting email addresses for North Polk Community School District users. Change settings

Compares the work input to the work output

- efficiency
- mechanical advantage
- potential energy
- power

Reflection

- Guessed
- Unsure
- Sure

Energy of objects in motion

- kinetic energy
- potential energy
- force
- efficiency

Force exerted over a distance

- ○ Work
- ○ Power
- ○ Energy
- ○ Force

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

Stored energy or energy due to position

- ○ Kinetic energy
- ○ Projectile energy
- ○ Potential energy
- ○ work

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

A baseball with a mass of 0.15 kg is traveling at a speed of 40 m/s. What is the baseball's kinetic energy from this motion?

- 6 Joules
- 120 Joules
- 100 Joules
- 12 Joules

Reflection

- Guessed
- Unsure
- Sure

It takes you 500 J of work to lift a piano onto the second floor of your home using a pulley system. Between the piano and friction, the work output is 300 J. What is the efficiency of the pulley system?

- 60%
- 600%
- 166%
- 30%

Reflection

- Guessed
- Unsure
- Sure

You drop a 10,000 kg watermelon off the top of the school which is 25 meters high. What was the gravitational potential energy prior to releasing the watermelon?

- ○ 245,000 Joules
- ○ 2,450,000 Joules
- ○ 2,450,000 Watts
- ○ 245 Watts

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

APPENDIX I

FORMATIVE ASSESSMENT #2 QUESTIONS

WPE Formative Assessment #2 (CG)

Form description

This form is automatically collecting email addresses for North Polk Community School District users. Change settings

Compares the work input to the work output

- ○ efficiency
- ○ mechanical advantage
- ○ potential energy
- ○ power

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

Energy of objects in motion

- ○ kinetic energy
- ○ potential energy
- ○ force
- ○ efficiency

Force exerted over a distance

- ○ Work
- ○ Power
- ○ Energy
- ○ Force

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

Stored energy or energy due to position

- ○ Kinetic energy
- ○ Projectile energy
- ○ Potential energy
- ○ work

Reflection

- ○ Guessed
- ○ Unsure
- ○ Sure

A baseball with a mass of 0.15 kg is traveling at a speed of 40 m/s. What is the baseball's kinetic energy from this motion?

- 6 Joules
- 120 Joules
- 100 Joules
- 12 Joules

Reflection

- Guessed
- Unsure
- Sure

It takes you 500 J of work to lift a piano onto the second floor of your home using a pulley system. Between the piano and friction, the work output is 300 J. What is the efficiency of the pulley system?

- 60%
- 600%
- 166%
- 30%

Reflection

- Guessed
- Unsure
- Sure

You drop a 10,000 kg watermelon off the top of the school which is 25 meters high. What was the potential energy prior to releasing the watermelon?

- 245,000 Joules
- 2,450,000 Joules
- 2,450,000 Watts
- 245 Watts

Reflection

- Guessed
- Unsure
- Sure

Which of the following would increase the mechanical advantage of a ramp?

- Adding resistance
- increasing the distance of the ramp
- increasing friction
- increasing the mass of the object being moved

Reflection

- Guessed
- Unsure
- Sure

Which of the following statements is true about the law of conservation of energy?

- Energy cannot be created
- Energy cannot be destroyed
- Energy can be converted to other forms
- All of the above

Reflection

- Guessed
- Unsure
- Sure

How much gravitational potential energy would a 5 kg object with a height of zero meters have?

- 49 Joules
- 49 Watts
- 490 Joules
- 0 Joules

Reflection

- Guessed
- Unsure
- Sure

APPENDIX J
STUDENT ENGAGEMENT SPREADSHEET

A	B	C	D	E	F
Time Frame	**Classroom Activity (L, SG, CD, PBL, IWT)**	**# of students engaged**	**# of students disengaged**	**Current action of most disengaged students**	
Date: 9-17					**KEY:**
9:20-9:25	just everyone settleing	17	0		Lecture
9:26-9:31	lecture	14	3	talking	Small Group
9:32-9:37	small group and instructions	13	4	distracted/talking	Class Discussion
9:38-9:43	hectic communication	17	0	talking	Project Based Learning
9:44-9:49	planning	17	0	on task	Individual Work Time
9:50-9:55	planning	15	2	talking	everyone is on topic
9:56-10:01	planning	14	3	random conversation	1-3 people are off topic
10:02-10:06	clean up and cool down	10	7	random conversation	4< are off topic
Date: 9-18					
9:20-9:25	small lecture	like 12	6	random chatter	
9:26-9:31	small group	16	2	talking about mason	
9:32-9:37	egg drops	18	0	on task	
9:38-9:43	egg drops	18	0	on task	
9:44-9:49	egg drops	18	0	on task	
9:50-9:55	egg drops	18	0	on task	
9:56-10:01	egg drops	16	2	small conversation	
10:02-10:06	clean up	18	0	on task	
Date: 9-19	your students were bored				
9:20-9:25	dose was late	0	18	caotic talking	
9:26-9:31	dose arrived, dailey review	16	2	small group talking	
9:32-9:37	extra egg drop time	14	4	talking	
9:38-9:43	extra egg drop time	16	2	talking	
9:44-9:49	extra egg drop time	12	6	talking and playing "what teacher am i"	
9:50-9:55	finding a slow mo app	16	2	talking	
9:56-10:01	finishing thir stuff and testing apps	10	8	litterly anything	
10:02-10:06					
Date: 9-20					
9:20-9:25	we started egg drops	18	18	everyone was haveing fun, but the were watching	
9:26-9:31	we did egg drops	18	18	"	
9:32-9:37	we did egg drops	18	18	"	
9:38-9:43	we did egg drops	18	18	"	
9:44-9:49	we did egg drops	18	18	"	
9:50-9:55	we did egg drops	18	18	"	
9:56-10:01	we did egg drops	18	18	"	