WHERE IN THE WORLD IS PHYSICS?

PHYSICS IN EVERYDAY LIFE

by

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DEDICATION

This capstone research is dedicated to my past, current and future students, my family, and my friends.

To the students who helped inspire this research by requesting to have tea in class and by appreciating my excitement when tea day included a physics lesson. To the students who were participants in the research, they pushed me to become a better teacher and were able to have a positive outlook on the process. For my future students, that they may benefit from this research and future ideas that stem from this process.

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TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

LIST OF TABLES

Table Page

LIST OF FIGURES

ABSTRACT

Connecting high school physics content to everyday life of students is challenging and with students having varying life experiences making connections with each student becomes even harder. By exploring physics through seminar days, inquiry and group activities, and student reflection, students were given shared experiences to make connection to their daily life. By connecting physics curriculum to our everyday experiences, we can learn to apply the basic concepts to investigate safety, learn about nature, space exploration, athletics, the universe, and even a cup of tea. Students participated in pre- and post-treatment surveys, exit slips, science journal reflections, and seminars were used as data collection instruments. Quantitative and qualitative data were collected and analyzed. The results showed the use of seminars and inquiry engaged students in learning. When asked to rank activities carried out in the treatment time, 85% of students ranked a seminar as their first choice for most engaging. Fifty to 85% of students ranked all three seminars in their top three choices.

INTRODUCTION AND BACKGROUND

Every year when it is time to sign up for classes, students ask me, "Is physics hard?" Without much hesitation, I usually respond with an enthusiastic, "Yes, but it explains how the world works which helps!" Most students look at me like I am crazy for admitting that my class is challenging, but a lot of them still sign up. When I was in high school, I had no idea what was happening in my Physics class. I had no idea what physics was, how it explained the world, or how it relates to my daily life. In college, I was riding my bike and casually found my brain creating a problem about another biker who has just passed me, I thought something along the lines of "if they turn around in two miles and I keep going at the same pace, how long would it take before our paths crossed again?" That is when it clicked, physics makes sense, and my brain is wired to think in physics. With time I decided I wanted to teach physics at the high school level. When I made this decision, I wanted to give my students a different experience than the one that I had in high school. I wanted to share the wonderful world of physics in a fun, hands on way, and work with students to relate their everyday experiences to make the content more relevant.

Context of the Study

I completed my eighth year of teaching at Dominican High School, a small Catholic high school, located in Whitefish Bay, Wisconsin just outside Milwaukee. Whitefish Bay is a small village just north of the city, surrounded by other small communities and bordering Lake Michigan to the east. Dominican High School was founded by Sinsinawa Dominican Congregation in 1956, having its first graduating class in 1960. The school has continued to build on the foundation the Sinsinawa sisters and priest over the years. The school strives to provide a competitive, faith filled education built on the core values of the Sinsinawa sisters, which are Truth, Compassion, Justice, Community, and Partnership. Dominican is a diverse community of students, that has a similar demographic composition to that of Milwaukee. According to our registrar office, we have 320 students this year and the ethnicity breakdown of the school is 46.8% Caucasian, 22.8% Black, 21.5% Hispanic, 5.4% Asian, and 3.5% other. Dominican's population comes from over 50 different feeder schools, 53.8% of the student body lives in the city of Milwaukee and the remaining 46.2% live in the surrounding suburbs. The student body comes from a diverse socioeconomic background as well. The student to teacher ratio is about 1:13 and 98% of our graduates pursues higher education. Dominican also participates in the Milwaukee Parental Choice Program that allows accepted students to attend a private school instead of their local public school, and their tuition is paid for by state aid payments per student. Each school year about 30-35% of the Dominican student population is able to attend through the Choice Program (Wisconsin Department of Public Instruction). The Dominican community is a strong, vibrant, faith filled, family-like community where we encourage and support our students to the best of our ability, and we continually preach that we know our students "by name, by need, and by gift."

Upon graduating with my undergraduate degree in Physics Education from the University of Wisconsin – La Crosse in 2014, I accepted the position at Dominican High School. I have completed eight years there, with a semester leave of absence to teach abroad in Zambia, Africa. Through both of my teaching experiences, it has come to my attention that physics is perceived to be challenging and students quite often remark that it is just another math class. Over the years, I have challenged my students and myself to make connections of the classroom content to their daily lives. I have noticed that each year more students are able to relate physics to their daily life on a conceptual basis and in turn it helps them to understand the concepts better.

Typically, students usually are able to be successful in the mathematical aspect of physics because it builds on their prior algebraic skills; however, the class provides challenges for them when applying the concepts to real life situations. These challenges can be for a variety of reasons including prior misconceptions, limited exposure to physics, and as I like to remind my students, physics has a lot of strange concepts. Often times these concepts seem unintuitive but are actually logical, making it difficult for some student to wrap their heads around them. Through increased application, questions, and reflection of how the material connects to their daily life, there seems to be an increase in student engagement and increase success on conceptual questions and assessments. When students have a hard time seeing how the content is applicable to their daily life, it can decrease their engagement and success in a class. Through this study, I aim to study different treatments and their effects on student learning and engagement and to better develop the connections between physics and their daily life. Physics is everywhere and it is not only important for students to understand the basic laws of physics that we can see in a classroom, but it is important for students to look at different situations and be able to analyze them through a scientific lens. Physics is foundational to our understanding of the natural and constructed worlds; we experience it every day. Through physics, we can investigate safety, learn about nature and the forming of the world and universe, problem solve for the future of space exploration and alternative energy sources. A few specific examples include, driving and impact of car crashes, sports and injuries like concussions, roller coasters, hydropower as an energy source, space explorations to Mars, and much more. By increasing relevant and applicable physics situations coupled with student reflection, this study aspires to increase student engagement and interest.

My philosophy of bringing science alive and to the personal lives of students is shared with my science colleagues, this study will be able to support our department as we strive to make science more applicable to the everyday lives of our students. Beyond the school, this research could be shared with feeder school as a way to develop middle school science classes, which in turn may help students to be more prepared for the high school science classroom. The information gathered will also be shared with my Zambian colleagues at the School of Hope. Through my research, I have not found many similar studies about the importance of bringing physics to life through the lives of the students. This study may be of some interest for other researcher investigating similar content.

Focus Questions

The focus of this study was looking at the integration of physics in everyday life, the main research questions was, What are the effects of connecting physics content to the everyday life of high school students?

My sub-questions include the following:

1. How does the use of real-world physics seminar days impact student learning?
2. What are best practices for connecting physics to students' everyday life?
3. How does personal reflection on physics effect student engagement?

CONCEPTUAL FRAMEWORK

The conceptual framework for this study is broken up into the following themes: (1) Current State of physics in High Schools, (2) Current Research Methodologies for Studying the Effectiveness of physics Application to Real World Physics Scenarios, (3) Teaching Practices and Techniques in Science Education, (4) Theoretical Verse Practical Physics, and (5) Next Generation Science Standards (NGSS) Cross Cutting Concepts and Science and Engineering Practices in Physics. These themes have been established based on the need seen in my classroom to increase the connection of classroom content to the everyday life of the student. Over the years, students have expressed their appreciation for being able to connect what we are learning to their life experiences, therefore, I stive to continue to develop new ways of making these connections and through this study have been able to use the following research to support my treatments to make even more daily life connections with my students.

Current State of Physics in High Schools

At Dominican, physics is considered an elective science class and as a science department, we encourage students to take at least one of the physics related course, so they have a more well-rounded science education. Over the years, we have seen our enrollment of students taking a physics class increase with the addition of physics related electives and decrease with non-physics electives. The average number of students taking a physics or physics related course in the last eight years is 70 students, with a low of 58 students during my first year and a high of 85 students in my fourth year. The numbers have dropped since then and remains close to the average number of students over the eight years. A 2018-2019 study (Chu, 2021) carried out by the American Institute of Physics shows an increase in high school students taking physics since

1987. From the schools that participated in the study, “US high school physics enrollment increased 12% since the previous survey was conducted in 2013, outpacing the 6% growth of high school seniors” (Chu, 2021, p. 1). This means that about 42% of high school students are taking at least one physics class before they graduate (Chu, 2021, p. 2). Another aspect this study looked at was teacher load, and of the teachers surveyed about half teach all physics or mostly physics courses (Chu, 2021, p. 3). At Dominican, I am the only physics teacher, and I also teach an algebra class.

The following studies discuss some of the current ways and perspectives of teaching physics and the importance of making changes to what has been done to increase student engagement and connecting physics to the real world. In study called *Physics: Frightful but Fun. Pupils’ and Teachers’ Views of Physics and Physics Teaching* (Angell, 2004) compares the perspectives of teachers to pupils in different areas such as importance of math, content interest levels, challenges of physics, importance of aspects of physics, role of experiments and some others. There is much variation on what students and teachers think and wish, for example about 23% of teachers thought they “very often” presented at the blackboard, whereas 60% of pupils said this happens very often, and about 45% of pupils wish it would happen very often. Another interesting question was about demonstrating concepts and about 75% of students wish it were more often (Angell, 2004, p. 698). It is beneficial to get student feedback on different treatments that happen, because what they think may be different than what the teacher thinks, which in turn could increase student engagement and even enrollment in physics courses. Another reason this study is important is because it investigated concerns about recruitment, class material, and teaching methods which may account for the decreased number of students pursuing careers in the field. This information can aid high school physics teachers to address the importance of connecting science to the everyday life and to increase interest. This will then hopefully encourage students to seek science careers as a part of a larger goal.

These goals have to begin with looking at how physics is taught in high schools and what are the most valuable areas in teaching physics to increase student engagement and connections to the real world. In an article from the *International Journal of Science Education* (Park, 2004), student interest in solving everyday physics problems, preference of everyday problems compared to normal content questions, analyzing the process of problem solving, and determining other factors that could affect student performance on everyday physics questions was examined. When teaching physics in light of everyday context, Park (2004) "observed that students showed no interest in everyday context when they did not have an experience with those contexts. Therefore, researchers stress that physics teachers need to let students experience or make inquiries into various everyday context before or during learning physics" (p. 10). It is important for the teachers to understand there could be other factors that affect student performance on different types of problems and personal experiences is an influential factor. Additionally, Murshed (2021) suggests the importance of using multiple representations to aid in studying physics and solving problems. This is a common practice in physics classes as identifying a system and what is happening in that system needs to be visualized. These representations include words, pictures, numbers, and comparative problems, this combined with following steps and applying prior knowledge to new problems is an important part of physics education. By asking students to model their problem-solving skills through multiple representations, is beneficial for teachers to follow the students understanding of the material (Murshed, 2021).

When creating science curriculum and lesson plans, integrating the classroom content to the everyday life of students is important and beneficial to student learning. The article, *The Role of Exploration in the Classroom (STEM)* (Yager, 2015), discusses what science is, what changes are needed in the science classroom and tools for how to reach that point. The author states that science should be more doing than just learning the concepts and processes. Some of the main points are by allowing for student creativity, encouraging positive attitude in science, then using all these things including the concepts and processes will allow students to apply what they know by making connections and help them develop a world view of science. This article provides a practical understanding of how science courses can be more focused on creativity, application, worldviews, and the importance of science literacy. Some of the goals as a part of the reform of STEM education are “failure is used as a learning device”, students can come “to understand the larger social, environmental, and cultural implications of any proposed solution to a problem”, and “all learners are well prepared to be active, thoughtful, engaged members of the public sphere” (Yager, 2015, p. 214). This helps derive how the world of education is influential for the lives of students beyond the classroom and supports how connecting concepts to the life experience is extremely beneficial to the learners we meet.

Current Research Methodologies for Studying the Effectiveness of Physics Application to Real World Scenarios

Real world scenarios are significantly more complex than the average high school physics curriculum. This poses a challenge in making effective choices about best teacher practices when creating methods to study application of curriculum. There is an abundance of research in science education and continual reworking of curriculums to develop skills and content that connects to STEM fields. Science education research has demonstrated the importance of increased student interest and critical thinking, and importance of inquiry and exploratory learning to student success.

The "Finding Physics" Project: Recognizing and Exploring Physics Outside the Classroom (Beck, 2016) discusses the importance of connecting physics classroom content to the everyday life of students. The project was designed to have students create and solve their own physics problems based on something they experience. Students used video games, their athletics, analyzing a movie/video clip, or something else that interested them. They then created a problem and determined the necessary information based on what they usually needed to solve a similar problem in class. After determining what they knew, they solved the problem and made critical reflection on their answer to determine if their answer makes sense, and if it does not make sense, they had to express why that might be. The outcomes of the project were a personal interest by the students into what they were investigating, increase physics conversations among students, their friends, and family, increased critical thinking, and the ability to get to know students better (Beak, 2016).

In looking into practices and techniques it becomes critical to identify student prior knowledge, be cognizant of how it can influence a lesson, activity, or assessment, and understand how it will affect a student's ability to connect material to their daily life. One of the challenges of making content relatable is that everyone has their own experience outside of school and some students have a more challenging time connecting their ideas to what they are learning especially if they cannot see how the material is relevant in their life. This article is also important for the reminder that students need the content background before they can explore their own lives.

A study by Anne-Marie Pendrill (2021), demonstrates an inquiry lesson which allows students to participate in an investigation and the share their results. Pendrill took groups of students to a playground to investigate factors that influenced different balls rolling down different inclined surfaces. Pendrill says that through this sort of activity, "students can develop an intuitive felling of these concepts even without dealing with the full mathematical treatment" (p. 1). This stresses the importance of having students get a sense of the physics happening around them which can increase their understanding of the conceptual material, that can transfer over to classroom learning.

Pendrill's activity allowed students to explore the world around them while working in small groups. The following research supports the use of small groups for student learning and collaboration by using context-rich problems which is influential in student understanding of material and how students used their prior knowledge of physics to solve the problem. Enghag (2007) investigated small group work and the conversations that were had in regard to solving an everyday life physics problem. Student conversations were recorded, and their "exploratory talks" were analyzed. The researchers analyzed the process students took to solve the problem, the development of the conversation, and participation of group members in solving the problem. Part of the analysis done on the conversation classified statements as everyday-life-experience, physics related, and remaining. The study showed that students were able to use their own experiences to approach successful learning (Enghag, 2007, pp. 449-467). When discussing in small groups or in large groups, it can be challenging to keep the inquiry process engaging for all students.

Even more importantly is establishing the foundation that students need for scientific communication, including vocabulary, structure, and ability to analyze. Pimentel and McNeill (2013) discuss the importance of science talk in science classrooms, breaking it down into organizational and thematic categories. Organizational looks at who is participating, whereas thematic refers to the specific content being discussed. Understanding my role as a teacher-facilitator in small group and whole group is crucial to student engagement and connecting with students more fully to build their confidence in the content. By knowing that "the teacher essentially establishes how students are allowed to interact during a lesson" (Pimentel, 2013, p. 4), is vital to the success of collecting qualitative data from these environments. Pimentel and McNeill (2013) suggest the following techniques for science talk in a classroom: "encouraging students' ideas, referring back to students' responses, asking open questions and encouraging other students to respond before giving evaluative feedback to responses" (p. 5).

According to Foote (2019), "Physics is a vehicle to train students in thinking critically, solving complex problems, modelling real world situation, and communicating technical information". Here I strive to use this same mindset in developing and implementing treatments to bring students to a deeper level of understanding of the physics they experience in their day-to-day life while teaching them skills along the way.

Teaching Practices and Techniques in Science Education

Some of the best practices in connecting physics to real life can be seen from the research in best practices in science education which include student exploration, inquiry, real world connections, seminar days, the use of Classroom Assessment Tools (CATs). Going beyond the surface of where physics education is, this theme goes deeper into looking at specific teaching practices and techniques which are beneficial to students. Some of the techniques discussed are the use of exploration and inquiry, use of Classroom Assessment Tools (CATs), small group work and importance of understanding students' prior knowledge.

Using the philosophy of student exploration in an educational setting helps bring concepts and processes to life by digging deeper into the creative mind of students, helping them make connections and introducing them to a bigger worldview of science. Yaeger (2015) stresses the importance of students making connections to their own life, and the challenges brought about by their differing individual experiences. Additionally, Yaeger (2015) expresses the need for "emphasis on teaching to produce…understanding and responding to individual student interests, strengths, experiences, and needs" (p. 211). Lastly, this article also states the importance of STEM literacy which relates to the theme of the importance of connecting content to the real-world, "Recognizing how STEM disciplines shape our material, intellectual, and cultural world" (Yager, 2015, p. 214).

Inquiry based learning, especially in the sciences, is important for student learning and understanding because "inquiry is an active learning process in which students answer research questions through data analysis" (Šlekienė, 2013, p. 2). The different levels of inquiry that have been developed and changed throughout the years, according to Bianchi and Bell (2008), but currently they include confirmation, structured, guided, and open. As you move through the levels of inquire, the structure lessens and becomes more independent for students to be able to "act as scientists, deriving equations, designing and carrying out investigations and communicating their results" (Bianchi, 2008, p. 2). Reaching these deeper levels of inquiry are what helped develop the treatments of this study.

Seminar days and field trips are important in engaging students, having them work in groups as well as develop science language skills through conversation and problems solving. These opportunities also give students the ability to make deeper connection between classroom content and a real-world context. According to a case study (Neilsen, 2008) on students attending an amusement park, working with peers, and problems solving, students were confronted with different problems, they needed to use their prior knowledge. This study specifically drew the conclusion that "problem-solving activities from the field trip and in-class activities enabled the students to develop deeper understandings of the kinematic concepts they encountered, enriching their prior conceptions" (Neilsen, 2008, p. 18). It is important to note that when students are exploring, they may not always draw upon the correct prior knowledge but working with peers can help students to process through to draw proper conclusions.

In supporting the importance of including real world examples to the classroom, a study by Christina Scott (2014), a biology teacher and former MSSE graduate student, conducted a similar study about how connecting her biology content to the real world influenced student learning and success. One of her findings was with a treatment connecting bacteria to a real-world documentary; she found there was an increase in student engagement and inquiry into the content. She also states one of her findings was that "as each unit progressed (she) noted there were more questions asked as part of their learning; they were intrigued by the applications" (p. 39).

In working to increase student exposure to real world physics, the use of seminar days was inspired by the "Tea Day" I had with my students. The value of studying nonspecific physics content allows us to relate something like a cup of tea to physics classroom content, which lead to exposing students to more real world physics connections to engage students. We used the book *Storm in a Tea Cup: The Physics of Everyday Life,* by Helen Czerski. In the book, Czerski (2017) states that a "benefit to knowing about how the world works…seeing what makes the world tick changes your perspective. The world is a mosaic of physical patterns, and once you're familiar with the basics, you start to see how those patterns fit together" (p. 11). In a study done on the *Effects of Students' Seminar of Learning in 1st Year MBBS* (Sabbani, 2020) Students used pre and post-test questionnaires to assess student learning from short seminars put on by their peers. Groups of students were assigned a topic to present in depth and then their learning was assessed to see if this method of learning was effective for students. The results of the study were that students showed increase in performance on the post questionnaires, student engagement and communication among themselves and with their teachers increased (Sabbani, 2020). Using this method presents a lot of qualitative data as it was an observational study, and information gathered from pre and post tests and questionnaires will be a method for more quantitative and qualitative data collection as well. The feedback questionnaire used in this study was a Likert scale and the data were turned into percentages of their opinions. The pre and post-test in this study were beneficial in interpreting change in student understanding of the content presented. Using pre and post assessments of some before a seminar day would be useful to understand if student learning increased because of the content presented and the use of a feedback questionnaire and personal reflection would be valuable for qualitative data to see the usefulness and connectedness of student engagement and perspective (Sabbani, 2020).

Another method of collecting data in this Action Research study is concept maps, which are extremely beneficial for students to demonstrate their knowledge of a concept and for the teacher to see how students are able to make connections between the material and beyond the classroom. A study carried out in Zambia, Africa through the Mukuba University and The Copperbelt University (2014) looked at a control group given worksheets and small group collaboration and discussion, the experimental group was taught what concept maps are and then they had to create one about the topic they were studying, circular & rotational motion. Both groups were given the same beginning lecture and the methods used to collect data were pre and post-tests, questionnaires, and semi-structured interviews. The data collected from concept maps is truly valuable in seeing where students are at and what material they understand and then using that as a method to see what connections they can make to the real-world. This study also used pre-test and post-test as a method of collecting data as well as student interviews. The researchers collected data through interviews by choosing two students who improved the most, two students who had similar results, and two students who did worse (Luchembe, 2014, p. 17). They then recoded the interviews so as to analyze the information better next time. The interviewees were asked about their interest, understanding, and the usefulness of concept mapping (Luchembe, 2014, p. 22).

When making connections to the real world another beneficial practice is to allow students to work in small groups. This allows students to build off of other group members experiences and knowledge to problem solve and collaborate. The following study explored the effectiveness of small group work as a teaching practice in nursing education (Wong, 2018). The value of small group work is that students have the opportunity to learn from each other, the classroom then also becomes student centered instead of teacher centered. In a 2018 study done in a nursing education setting, Wong (2018) found that small groups helped students take what they learned in lecture and lab, then apply it to new situations. The study also looked the amount of time spent doing group work and the most effective size of a group for learning to occur at its greatest. Too much group work and some students may have a harder time engaging especially if their ideas are not liked, even though resolving conflict is important. The group sizes discussed in this study were on average 5-10 students depending on the project. The researchers also recognized the importance was balancing the group size based on the amount of work needing to be accomplished (Wong, 2018, p. 4).

Theoretical Verse Practical Physics

In my experience, students have experienced challenges when looking at practical connections of physics content compared to the more theoretical aspects of physics, which occurs when solving problems. One specific example is when students are able to solve problems mathematically but have challenges taking that number and thinking about what that means or could look like in the world around them. In an article called *Cars and Kinetic Energy – Some Simple Physics with Real-World Experience,* Dr. Parthasarathy (2012) discusses how to bring the real-world relevance of cars, specifically how to determine their kinetic energy and how much power they use, and the important of understanding energy and its influence on the world. The derivation of determining how much power a car needs is explained and the used to help students draw connections between why a car needs less power than it actually uses and how efficiently a car uses its energy. This is then used to discuss the automotive industry, gasoline versus electric cars, what goes into making a car more efficient and more applications. The article states that this material is used in non-science-major undergraduate classes “that aims to provide an understanding of the physics of energy and the environment” and “an understanding that physical analysis of real-world concerns is both accessible and rewarding”

(Parthasarathy, 2012, p. 4). Looking at how Parthasarathy broke down the content and explained how we make some assumptions to simplify our understanding we can help students engage in conversation and critical thinking about how factors in the real world are not always seen in the classroom and making connections between the theoretical and practical.

Another study completed across multiple Vietnamese high schools (Ng, 2006) investigated the use of teachers using everyday physics examples in class and its effect on student learning. The researchers found an increase in student engagement, problems solving skills, data analysis, and creative thinking. The overall findings were that most teachers agreed that by integrating everyday phenomena, students understand the concepts better. All of the teachers say they use experiments as demonstrations but do not have students do experimentation and the frequency of these demonstrations is not very often. Overall, the teachers seemed to agree that there is value in teaching the connections to real life and these connections should be assessed theoretically and practically (Ng, 2006, pp. 36-50).

NGSS Crosscutting Concepts and Science & Engineering Practices in Physics

The Next Generation Science Standards (NGSS) are extremely valuable science standards that encourage students how to learn and think (Anderson, 2019). As a school, Dominican does not use NGSS, so when looking into how to integrate the standards into this Action Research, I determined it would be most beneficial to my students to focus on the Crosscutting Concepts and the Science and Engineering Practices. Crosscutting Concepts are designed to facilitate students in making interdisciplinary connections in different branches of science and engineering. The Science and Engineering Practices push students to see the depth of inquiry in science and encourages them to "apply their knowledge of core ideas and crosscutting concepts" (NGSS Lead States, 2013). An important aspect of NGSS is helping students reach achievement levels of standards, through balancing the standard with crosscutting concepts, science and engineering practices, and a variety of assessment types. It is important to provide students the opportunity to demonstrate growth through multiple assessments in a single unit and to circle back to content in following units so students can continue to learn from the repetition.

METHODOLOGY

In this study, I developed instruments to specifically relate physics in the real-world to my curriculum with the goal to improve student engagement. The research for this project was carried out in the 2021-2022 school year. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A). Data collected for this AR project consists of student survey & reflection, assignment & assessment questions, small group work, and teacher reflection. These instruments are being used to aid in answering what are the effects of physics seminar days, what are best practices, and how student reflection on physics in their daily lives' effects engagement. Figure 1 presents a Data Triangulation Matrix that identifies which methods are being used for each research question.

Table 1. Data triangulation matrix.

	Data Collection Instruments			
Research SQ. 1: How does the use of real-world physics seminar days impact student engagement?	Student Surveys	Seminar	Science Journal Reflections	Assessments
Research SQ. 2: What are best practices for connecting physics to students' everyday life?	Student Surveys	Seminar	Science Journal Reflections	Assessments
Research SQ. 3: How does personal reflection on physics in their personal lives effect student engagement?	Student Surveys	Seminar	Science Journal Reflections	

Both quantitative and qualitative data was collected to analyze the data pertaining to each research question from multiple data sources. are used in this study to gather both quantitative and qualitative data from multiple different methodologies to analyze the data pertaining to each research question from multiple data sources. Data from multiple sources allows cross-examination and correlations to be drawn that more fully represent the outcomes of the study.

Demographics

In the 2021-2022 school year, my teaching assignment includes two sections of Advanced Physics, one section of regular physics, algebra, and astronomy. There were 29 students in Advanced Physics and students in these two classes were asked to participate in this Action Research project. Of the 29 students, eight are females, twenty are males, and zero identify otherwise. The following ethnicities make up the students in this study: 71% identify as Caucasian, 18% identify as Hispanic, 7% are Asian, and 4% identify as black. Seven of the students are juniors and 22 are seniors. Students are from all around the city of Milwaukee, from inner city to the suburbs and make up a wide range of socioeconomic backgrounds; this data is not collected specifically by our school. Seeing as the student population at school is 320 students, the number of upper classmen taking the elective physics class is small and not a direct reflection of the student body at our school, this provides a constraint on the study.

Treatment

This study was carried out during multiple units including freefall, forces, and energy. The treatment began in October 2021 and was completed in April 2022. The overall curriculum was kept the same as previous years and instruments were added to increase lessons that included more real-world connections. In the freefall unit, two activities were added, and an introduction lecture was changed from previous years. Normally, I start each unit with some background information in a short lecture form, this year I began with a 5E Inquiry lesson and lecture combination. Students conducted a freefall inquiry experiment where they collected data and made Claims, Evidence, and Reasoning (CERs) to share with the class. After completion we elaborated through note taking and watching five videos that demonstrated objects in freefall where students needed to write CERs. The next change to the freefall unit was an assignment where students needed to create their own real-world freefall problem and record a video of the scenario. Using this scenario, they had to describe the situation conceptually and mathematically. The unit ended with a normal unit celebration (this is what I call tests in my classroom) which includes a take home portion of the mathematical portion of the unit. The Force unit curriculum remained the same as the previous year, which included the motion concept map.

The one addition was the Wisconsin Glaciation Seminar, where we took a week to study Wisconsin glaciation and went on a field trip to Kettle Moraine State Park to observe formations left by the glaciers and hike along the Ice Age National Scenic Trail which maps out the edge of where the glaciers extended. This content was independent from the unit; however, we connected the physics content we had learned so far in class to further our understanding of how glaciers and the formations the leave behind relate to physics. The Energy unit remained the same besides the addition of the Physics of the Olympics Seminar Project and Tea Day Seminar. The Physics of the Olympics seminar occurred during February when the Olympic Winter Games was occurring. Students were asked to choose a sport from this year’s games to mathematically and conceptual analyze the physics occurring throughout the event. Students then presented their findings through an oral presentation of a poster which summarized their research. Tea Day Seminar occurred after the final assessment for the Energy unit. This year is the second annual Tea Day Seminar, during which we enjoy a cup of tea and read section of Helen Czerski's book *Storm in a Teacup: The Physics of Everyday Life* (2016) that describes patterns we can see in our teacups to other areas of the world and universe. Some assessment questions were given following tea day that were included on the final energy assessment.

Data Collection and Analysis Strategies

The following instruments were used during the treatment period of this study: pre- and post-surveys, student reflection, concept maps, seminar days, exit slips, and small group work; the treatments described below were carried out in the order they appear in here. Each treatment had its own specific way of analyzing data described below, in addition, all qualitative data was coded and anonymous. Simple statistics were carried out on quantitative data and themes were identified and analyzed from qualitative data.

Pre-Treatment Survey

Treatments started with a pre-treatment survey given to students on Microsoft Forms (Appendix B). Students were asked general questions about their engagement in class in general, in the activities that occurred in class before the survey date, and what are their perceptions of what helps them learn the most. They also had to rate their confidence level in making connections to their everyday lives, how many times they made connections outside of class, and what content they had found most interesting so far.

Data collected from surveys was consolidated into one form, using Microsoft From and observations were made about responses, Likert scales and open-ended questions were also used in these surveys. Means, medians, modes, and paired t-test were calculated and graphed. Responses to open ended questions were grouped by themes.

Motion Unit Instruments

Most of the first semester in physics was spent investigating, describing, understanding, and interpreting motion. The concepts learned in these first units are fundamental and foundational to the rest of the school year. Many instruments were carried out during the Free Fall Unit, students started the unit with a Freefall Inquiry (Appendix C) followed by a Freefall Lecture with videos (Appendix D). They then had to complete an assignment to create their own freefall problem (Appendix E), an exit slip after a take home celebration (Appendix F), as well as some assessment questions (Appendix G).

In the Free Fall Inquiry lesson (Appendix C) students were engaged in the new unit on free falling objects when dropping a bowling ball, students then made observations when dropping a tennis ball and the bowling ball at the same time from the same height. We discussed what they saw, next they were asked to create a simple experiment about objects in freefall, record their procedure, data, and observations, and write a conclusion. Each group of students was given the following objects: paper, table tennis ball, tennis ball, bouncy ball, balloon, leaves, pens and a slinky. During this activity, I collected data every four minutes from students, for a total of four times, by asking them to pause and answer if they were or were not understanding, interested, and engaged. Students circled their answers and then continued with their experiments. Following their experiments, we shared the design of their experiments and their findings, then completed an exit slip. This exit slip asks students to identify the most important take away, content they can connect from the lesson to their daily life, who might use this in their day-to-day, rated the practicality or theoretical nature of the topic, and their engagement.

For the data collected during the Freefall Inquiry activity, the results from student responses to the statements: (1) I am understanding/not understanding this activity. (2) I am interested/not interested in what is happening. (3) I am engaged/not engaged in this activity, were tallied and trends were established based on changes to student responses over the course of the activity. This data will provide evidence for my research questions on student engagement with real world content. Responses were graphed to compare trends in interest, understanding, and engagement for this group activity. The exit slip asked students the most important take away from the lesson, data will be analyzed to support the research questions about best practices and student engagement when connecting physics content to the real world. The first three questions were analyzed on a scale of zero to two, zero being students did not answer the question or their response did not address the appropriate topic or question being asked, a one was given when students had part of the appropriate response but were missing key information to demonstrate full understanding, a two was given when students who demonstrated their full understanding of the concept in their response. For example, a response was categorized as a two if they discussed both the ideas of freefall and real-world factors or a specific example. However, if a student discussed freefall but did not mention any real-world factors their response was recoded as a one, and if there was no mention of freefall or real-world factors then it was recorded as a zero.

The day after the Freefall Inquiry, we extended the lesson by going beyond and looking at real world factors that effect objects in free fall, through a background lecture and videos (Appendix D). We watched five videos of objects in free fall and students had to make a CER for each of the videos. At the end of the lesson, students completed an identical exit slip to the Freefall Inquiry, data will be analyzed to support the research questions about best practices and student engagement when connecting physics content to the real world.

Data collected from the Freefall lesson will be used to compare the use of inquiry verses traditional lecture to provide evidence for best teaching practices. Responses were collected, averages were taken and then graphed and compared. The responses on the exit slips were recorded on the same scale as the Freefall Inquiry exit slips.

The other treatment in this unit was an assignment at the end of the unit where students worked with partners to create their own projectile problem to match the video they recorded (Appendix E). Students chose an object and projected it straight up, horizontally, or at an angle, took measurements for the distance it traveled and the time it was in the air, then worked it backwards to determine the initial velocity at which they threw the object. Students were asked to show their work and then make observations about real world factors that would ultimately affect the object's motion and how the numbers they calculated would be different if those factors were included. They then had to represent their problem using a stack-o-graph, which is a stacked version of a position-time, velocity-time and acceleration-time graph to represent the motion of the object in their problem. Upon completing the activities students were asked to complete an exit slip about the activity, again the same as the Freefall Inquiry. The last two instruments in this unit were an identical exit slip (Appendix F) about a take home celebration and some assessment questions on their in class unit celebration. On summative assessment, questions were marked with RWQ, which means Real World Questions, to help students identify that they needed to include real-world factors when answering the question.

Student videos were graded on a rubric, but the scores were not used as they do not provide relevant data to support the research question. The two exit slips were scored on the same scale as the Freefall Inquiry exit slip and then compared to see what students rated their engagement. Data from this was also used to determine best teaching practices. Student scores from their unit assessment on real world questions were scored on the same zero to two scale as the Freefall Inquiry exit slip, these responses were compared to other assessment questions averages.

Force Unit Treatments

Students created a concept map about all the knowledge we have learned about motion, which needed to include real life examples of the concepts. Students were able to draw on their previous in class activities and notes to help them complete this task (Appendix H). The motion map of student knowledge as it relates to the real world acted as a mid-way assessment to see if instruments used in the prior units and information from implemented instruments were effective.

Motion maps were initially organized into two categories, including real world examples, or not including real world examples. Then the pile of concept maps that included real world examples was split into three more groups, which included one to three real world examples, four to six real world examples, and seven or more real world examples. This data was used to provide evidence for best teacher practices.

<u>Seminars</u>

Seminars are defined as days where we learn about non-physics curriculum topic and connect the content from our physics curriculum to the seminar topic. The following four seminars were used: (1) Wisconsin Glaciation Week, (2) Physics of the Olympics, and (3) Tea Day and (4) a Stream Science Journal. The first seminar was a Wisconsin Glaciation seminar on how glaciers formed the landscape of Wisconsin. We took a week of class time to discuss what glaciers are, how they form and shape the landscape, and how we can connect these ideas to physics. The week consisted of two class periods of background information, one day on a fieldtrip, and one day to reflect on where students saw physics on the fieldtrip. The fieldtrip was to Kettle Moraine State Park, where we hiked along the Ice Age National Scenic Trail and observed the formations left behind by the glaciers during the Wisconsin Ice Age. Students did some initial background research, participated in a lecture and class discussion, wrote a science journal reflection, and completed an exit slip about their engagement and to convince the principal to either keep or cancel the fieldtrip in the coming years. Students also shared their thoughts on what could make the seminar week better next year (Appendix I). On their final exam, students were asked a question that pertained to the content covered during this seminar (Appendix G).

Data from their exit slip was analyzed for trends on their thoughts for keeping or cancelling the field trip for next year. Their average engagement in the content of the week and the fieldtrip itself was compared to other exit slip averages across different instruments. Scores from their exam question were ranked on the same zero to two point scale as the exit slips and the averages compared to the other assessment question responses.

The Physics of the Olympics Seminar was a weeklong project where students picked a winter Olympic sport which they had to analyze the physics of that sport conceptually and mathematically. In great detail, students discussed the conceptual aspects of the sport they chose and were asked to make calculations based on actual or assumed numbers from the 2022 Winter Olympic athletes (Appendix J). Students were asked to research the history and rules of the sport as well, they then created a poster and presentation to demonstrate their understanding of the physics of their sport. After presentations students complete an exit slip that was the same as the Freefall Inquiry.

Student scores for their analysis, presentation, and posters were not used as data, however observations of their work and engagement were made and compared to student responses on their engagement in this seminar. Exit slips responses were recorded on the same zero to two scale as the Freefall Inquiry and compared to other exit slip data. Students reasoning for their engagement ratings were used to support the use of seminar days.

The last seminar was Tea Day, were students participated in a class demonstration and discussion about how you can relate physics to a cup of tea (Appendix K). Tea Day is a day in which as a class we all have a cup of tea (or hot chocolate) and discuss the physics that happens as it relates to the cup of tea and then taking what we observe in our cup of tea and relate it to the rest of the world. This activity began in the 2020-2021 school year and is now being used as an instrument for data collection in this Action Research project. In the winter of the 2020-2021 school year, my students asked if we could have a class period where we all drink a cup of tea. I love tea and would often have an afternoon cup of tea during their class, so naturally they wanted to join in. When I agreed, I knew I needed to bring in physics somehow and I stumbled on the book, *Storm in a Tea Cup: The Physics of Everyday Life* by Helen Czerski (2016), which has been the initial inspiration in the formation and development of this action research. From this book, I learned that making a cup of tea is connected to so many areas of physics. By boiling water, the process of convention occurs, which is the same process that happens inside the Earth's layer of liquid rock and the convection zone of stars. When mixing milk into a cup of tea, swirling patterns are observed and can be related to how weather happens in the atmosphere (Czerski, 2016). What I love about the book is how it takes the simple things in life and breaks the physics down into something that is understandable and applicable to everyday like popcorn popping can be compared to rockets, how spilled coffee evaporates can be related to heat buildup in goggles, and much more. The overview of Tea Day includes making tea, then as we enjoy the tea, I read segments aloud from Czerski's book to facilitate discussion about the patterns of convection, the mixing of hot and cold liquids, and the sloshing of liquid in a cup. When reading the excerpts, we stop and discuss the physics vocabulary used and how we can relate what Czerski describes to the physics content we have learned. After the Tea Day Seminar, students completed an exit slip (Appendix K) and had a couple of assessment questions (Appendix G) about content of the seminar day. Tea Day Seminar data from exit slips was scored on the same zero to two scale as the Freefall Inquiry exit slip, as were student responses to the seminar assessment questions. Averages of these data were compared to other exit slips and assessment questions given apart of different instruments.

The last seminar was a Stream Science Journal (Appendix L) where students found a stream or river near where they lived and observed the stream to draw conclusions about the physics they could see in nature. Students were asked to complete this seminar independently, on their own time. This assignment was completed twice, once at the beginning of the school year and once at the end of the school year. Student observations and scores were collected to draw conclusions about their growth from the beginning to end of the year. The template students used were the same as the templates for all other science journals, explained in the next section.

Science Journals

Students completed Science Journals at the end of most units (Appendix L) and were asked to reflect on the content we were learning then relate the content to their daily lives, including pictures and or videos. Students used Microsoft OneNote to keep all science journals together. Some used a stylus to write and draw, some typed and some chose to audio record their responses.

Science Journal reflections were analyzed for common themes to see if there was growth in the use of physics vocabulary from the beginning of the school year to the end of the school year. Students completed a science journal on a stream or river they live near to discover how the themes of physics can be applied to something in nature. Students had to do this at the beginning of the school year and then at the end of the school year with the hopes to see growth. These two Stream Science Journals were compared using word clouds generated by students written responses to visually represent what vocabulary were most prevalent. The average scores of student's science journals over the course of the year were graphed to investigate any trends.

Post treatment Survey

Treatments concluded with a post treatment survey given to students on Microsoft Forms (Appendix M). Students were asked similar question to the pre-treatment survey about their engagement in class in general, what their perceptions of what helps them learn the most, their confidence level and number of times they made connections to their daily lives. Students were also asked to rank the instruments used during the treatment time from most to least engaging and in order of most to least helpful when making connections to their daily life.

Data collected from post surveys were consolidated into one form, from this data, observations were made about responses, Means, medians, modes, and paired t-test were calculated where relevant. A paired t-test was used to compare student's pre and post treatment responses for questions 1, 4 and 6 on the survey. Graphs of mean scores were made for certain questions and themes were established from open ended questions by looking at responses and grouping like comments together to create themes. Ranking questions were graphed based on percentage of which student chose which activity.

DATA ANALYSIS

Results

Data Relating to Sub-Question #1

The impact of real world seminar days was measured through the use of exit slips, student science journal reflection, pre- and post-treatment surveys, and assessment questions. Figure 1 below represents the mean scores of students answer to the exit slip question about how helpful the activity was in their engagement in class, based on a scale from 1 to 5 with 1 being low and 5 being high. From the averages, the greatest value of 4.87 came from the seminar on Wisconsin Glaciation (*n*=23), where we took a fieldtrip to a close by Wisconsin State Park called Kettle Moraine, the next highest engagement average came from Tea Day Seminar (*n*=22), with an average of 4.23. Student engagement with the content from the Wisconsin Glaciation Seminar averaged was a 4.17, and the lowest average score was 3.30, from the Physics of the Olympics Seminar (*n*=27). Not only can this help student engagement, but it can help students make connections beyond the content. One student reflected that the most important take away from Tea Day was that "Physics can be studied on a small scale in real life and then applied to larger problems."

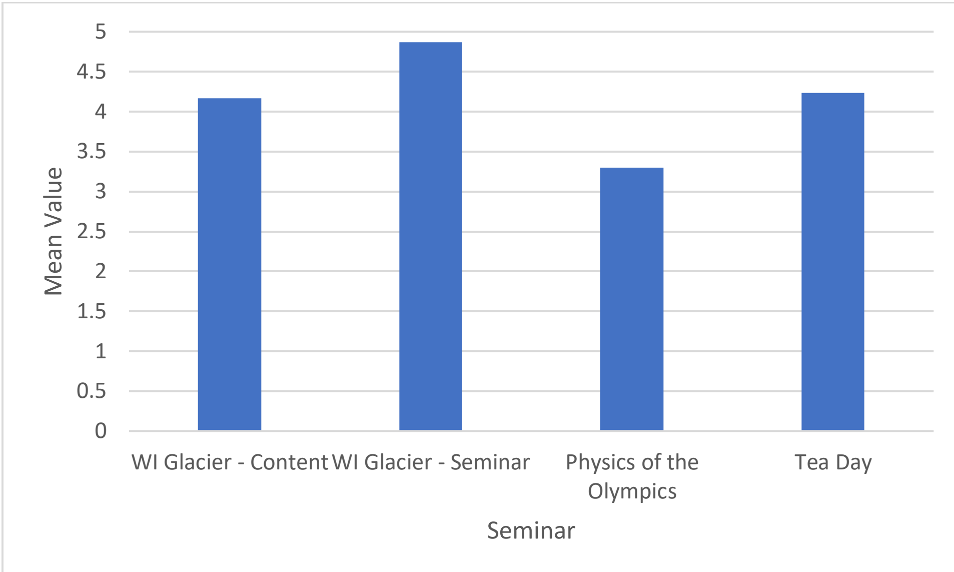
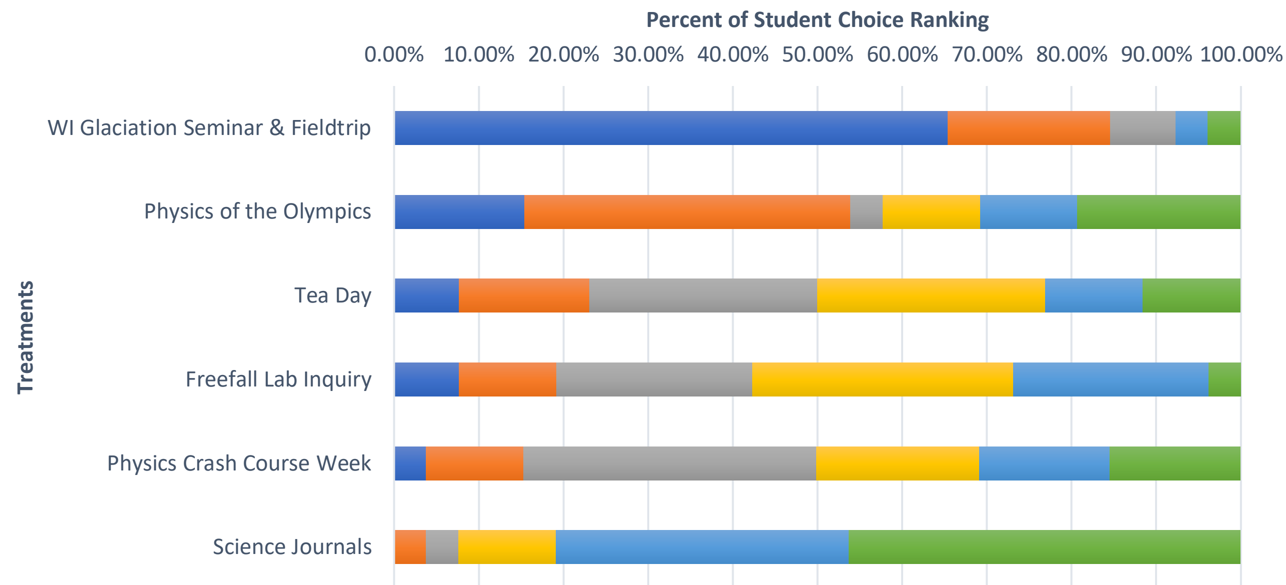


Figure 1. Mean values of student engagement in seminars.

Figure 2 shows students ranking of most of the treatment activities from most to least engaging. We can see that the Wisconsin Glacier Seminar had the highest first choice (65.4% as first choice) and the Science Journals had the most last choice in the ranking (46.2% as sixth choice). When looking at all three seminars, the Wisconsin Glacier Seminar, Physics of the Olympics, and Tea Day, 88.5% of students chose a seminar as their first choice. Of the 11.5% of students (three students) who did not choose a seminar for their first choice, two of the students chose a seminar as their second choice.



	Science Journals	Physics Crash Course Week	Freefall Lab Inquiry	Tea Day	Physics of the Olympics	WI Glaciation Seminar & Fieldtrip
1st choice	0%	3.80%	7.70%	7.70%	15.40%	65.40%
2nd Choice	3.80%	11.50%	11.50%	15.40%	38.50%	19.20%
3rd Choice	3.80%	34.60%	23.10%	26.90%	3.80%	7.70%
4th Choice	11.50%	19.20%	30.80%	26.90%	11.50%	0%
5th Choice	34.60%	15.40%	23.10%	11.50%	11.50%	3.80%
6th Choice	46.20%	15.40%	3.80%	11.50%	19.20%	3.80%

1st choice 2nd Choice 3rd Choice 4th Choice 5th Choice 6th Choice

Figure 2. Rankings of treatment activities from most to least engaging from post treatment survey.

Based on a small sample of assessment questions (Table 2), it can be seen from the average scores there is no significant score difference between student performance on assessment questions based on seminar days compared to the freefall unit real world questions (RWQ).

Table 2. Average scores on assessment question based on real world scenarios. (All scores are averaged out of two except the Real World Final question which was out of 4*).

Unit Without Seminars						
Topic	Freefall 1	Freefall 2	Freefall 3	Freefall 4 - Final	Freefall 5 - Final	Average of Averages
Average	1.65	2	1.65	1.93	1.76	1.798

Seminar Related Questions					
Topic	Tea 1	Tea 2	Tea 3	Average of Averages - Tea	WI Glacier
Average	1.83	1.74	1.35	1.64	1.37

Other Real-World Questions				
Topic	Energy 1	Energy2 - Final	Averages or Averages - Energy	Real World* - Final
Average	1.96	1.27	1.62	3.64

<u>Data Relating to Sub-Question #2</u>

Best practices for connecting physics to student' everyday life was analyzed through data from pre- and post-treatment surveys, exit slips, a concept map, and a Freefall Inquiry. When students were surveyed during the pre and post treatment survey, students were asked to identify what in class method(s) were the most helpful to their learning, these results are shown in Figure 3. About half the students surveyed responded that working with others was helpful to their learning, more students identified lab/activities and practice problems were the most helpful. Both categories increased in the number of students showing that small group or partner activities/labs and practice problems are beneficial teacher practices in general.

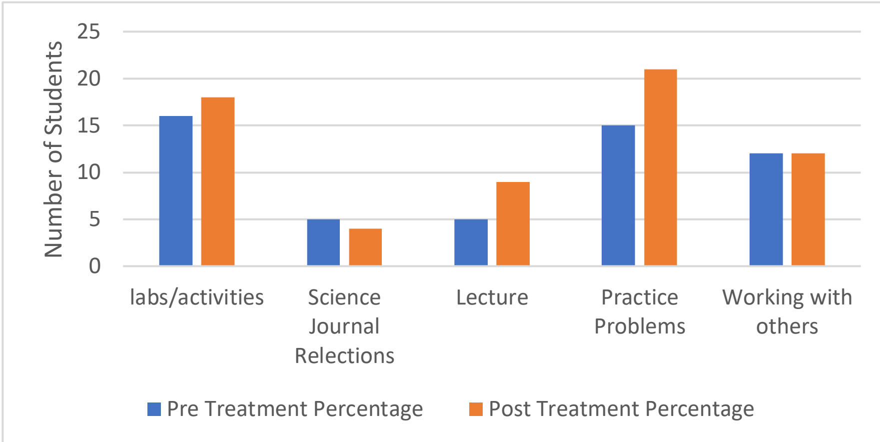


Figure 3. Activities Students find most helpful, pre and post treatment survey.

When looking for best practices while connecting physics in everyday life we have to look into more specific data. When analyzing the pre and post treatment survey (n=24) a paired t-test was complete for questions that included numerical rankings or could easily be converted into a scale. Since n=24 is less than 30, the value of data points needed to normally complete a paired t-test, we cannot us the Central Limit Theorem for normality, however a normal probability plot of the differences ($post\ scores - pre\ scores$) shows a relatively linear pattern, so the sample data is approximately normal and we can use a t-distribution. In Table 3, the statistical data is shown for Question 1 of the pre and post treatment survey. This gives us an overall view of student's thoughts on their enjoyment in leaning physics from the beginning of the treatment compared to the end of the treatment. The results shown in the table from the paired t-test show that there was no significant change, meaning that there is no statistical evidence to show that students' enjoyment of learning of physics changed over the course of the treatments.

Table 3. Statistics on Question 1 of the pre and post treatment survey.

Question 1. I am enjoying learning about physics. Strongly agree (1), Disagree (2), It's okay (3), Agree (4), Strongly Agree (5).			
Question Statistics			
	Pre	*Post*	*Difference*
Mean	3.958	3.583	-0.375
Median	4	4	0
Mode	4	4	0
Standard Deviation	0.751	1.1	1.013

Hypothesis
µd= true mean difference in the post score - pre score
Ho - µd=0, no change
Ha - µd ≠ 0
α=0.05

Paired T-test Results
t-stat = -1.831
p-value = 0.083
95% CI* = (-0.803, 0.053)
Because p-value is greater than alpha, we fail to reject Ho. There was not enough evidence to say that there is a difference in the post and pre scores.

In Table 4, the statistical data is shown for Question 4 of the pre and post treatment survey regarding student engagement in class, their confidence level in making connections to physics in the real world, and their engagement when working with small groups or a partner. From our statistical analysis, we can see student engagement (question 4a) does not have statistical data that supports any change in student engagement over the course of the treatments. We can also see from Question 4c, student engagement when working with small groups or partners did not change either. However, in the results of the paired t-test we saw a negative change in student confidence level in making connections to the real world from the beginning to the end of the treatment time.

Table 4. Statistics on Question 4 of the pre and post treatment survey.

Question 4. Rate the following statements, five (5) is considered high and one (1) is considered low.

4a - Rate your engagement in class so far.
4b - Rate your confidence level when making connections to physics in the real world.
4c - Rate your engagement when working with small groups or a partner.

Question Statistics									
	4a			4b			4c		
	Pre	*Post*	*Diff*	*Pre*	*Post*	*Diff*	*Pre*	*Post*	*Diff*
Mean	3.67	3.75	0.083	3.96	3.54	-0.417	4.25	3.875	-0.375
Median	4	4	4	4	4	4	0	0	0
Mode	4	4	4	4	4	4	0	0	0
Standard Deviation	0.701	0.896	0.654	0.955	1.32	0.974	0.608	0.947	1.096

Hypothesis for all parts of question 4
µd= true mean difference in the post score - pre score
Ho - µd=0, no change
Ha - $\mu d \neq 0$
α=0.05

Paired T-test Results			
	4a	*4b*	*4c*
t-stat	0.625	-2.095	-1.676
p-value	0.539	0.047	0.107
95% CI*	(-0.193, 0.359)	(-0.828, -0.005)	(-0.838, 0.088)
Result Statement	Because p-value is greater than alpha, we fail to reject Ho. There was not enough evidence to say that there is a difference in the post and pre scores.	Because p-value is less than alpha, we reject Ho, that there is a difference in post and pre scores. There is evidence to say that there is a difference in the post and pre scores.	Because p-value is greater than alpha, we fail to reject Ho. There was not enough evidence to say that there is a difference in the post and pre scores.

Figure 4 below shows us which of the activities surveyed were the most helpful to student engagement. The Wisconsin Glacier Seminar (n=23) was the most engaging and the Physics of the Olympics Seminar (n=27) was the least engaging. When looking at additional observational data drawn from student scores when they created a freefall problem video, students demonstrated clear understanding of the material studied in class, expressed enthusiasm while creating the videos, as well as deep understanding of real-world factors that would affect their calculation. Students responded to exit slip about this treatment by saying, the most important take away from today's activity is that "I can model real life things with math", "it was pretty engaging going to the gym and figuring things out", and "it was fun and good application". Student scores on the freefall problem could not be used to show true understanding of material because many students did not turn in all materials needed for the assignment. When looking at student responses to the Physics of the Olympics Seminar there was one insight made about why it may have had lower engagement. One student said, "Because of the work time and talking with you, I was able to get some out of it. Without your help I don't think I would have gotten much out of it." On the other hand, students were able to see the connection to their everyday life by stating, "it show how we can see these basic ideas/concepts of physics in everyday life such as these sports" and expressing their enjoyment of the project one student replied, "It was very fun to watch the Olympics and then actually calculate real things about real events."

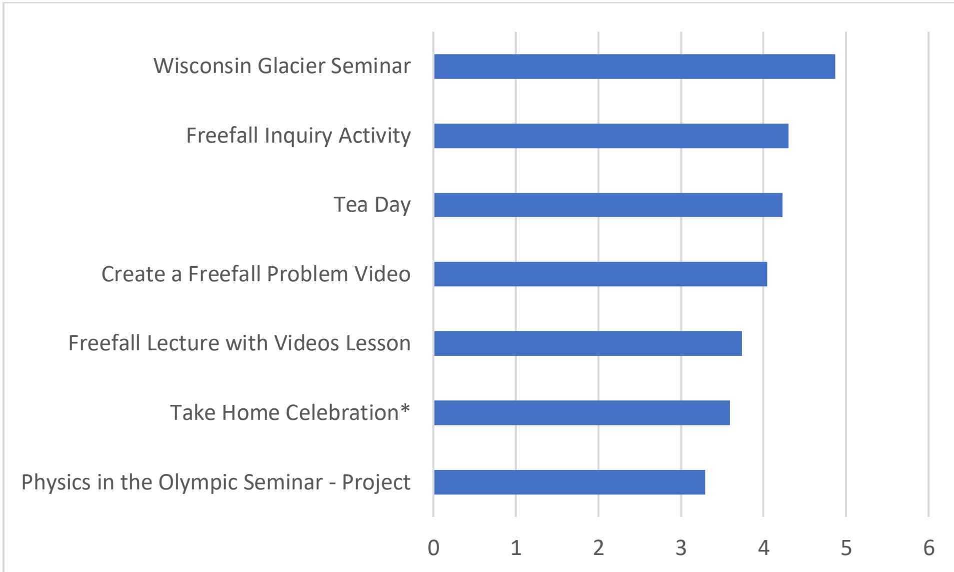


Figure 4. Mean scores for how helpful the activities were to student engagement in class.

When looking at students' response on the post treatment exit slips, we find more evidence to support the claim of seminar days, and small group work and inquiry are best teacher practices. When looking at student responses from the create a freefall problem video, one student wrote that the most important thing they learned was that they "can model real life things with math" and another said, "it was fun and good application". Another student said, "it was pretty engaging going to the gym and figuring things out."

Figure 5 summarizes the mean scores of student responses to questions 1-4 of the exit slips given at the end of each in class treatment. The highest mean score for Question 1, which asked students to identify the most important take away from the activity of the day, came with the Freefall inquiry, supporting the idea that inquiry is valuable to student understanding and engagement (see mean score from Figure 2). The lowest mean score came from the Freefall Lesson video, which student had a challenging time identifying the most important take away but were able to better identify who/what might actually use this in their day to day life (Question 3), the mean score was, 1.7. As a whole, question 3 had the overall highest mean scores across all exit slips, this shows that students were able to apply their knowledge of the content to possible careers or occupations that might use the content we learned. Question 1 had the lowest overall averages followed closely by the overall averages from Question 2 which asked what content from today could students take and connect to the real world or their daily life. This data identifies there can be a disconnect between student understanding of a lessons main point or how it connects to their personal life, however they may still be able to identify people who could use this knowledge in their everyday life. Question 4 on the survey asked students to rate the lesson or activity on a scale of mostly theoretical, somewhat theoretical, both, somewhat practical, or mostly practical (this question is on a scale of 1-5 compared to a scale of 0-2 for the other questions). Most of the treatments were designed to focus on including the practical real-world applications of the content. Students rated the Take-Home Celebration with a mean score of 3.14, which was the lowest mean average making the Take-Home Celebration the least practical treatment according to the students. In addition, students rated the take home celebration as one of the least engaging activities, one student said, “I don’t see a connection between the test and my engagement.” On the contrary, one student did reflect saying this about the take home celebration, “It was engaging because discussing happened a ton and it is helpful to talk to people.” According to students, the most practical treatment was creating their own freefall problem and identifying real world factors that would affect their calculations (mean score of 3.91), which was followed closely by the Tea Day Seminar (mean score of 3.86). Despite students lower mean scores for identifying the most important take away or how they can relate the content to their lives, students were able to identify the practical nature of the content covered.

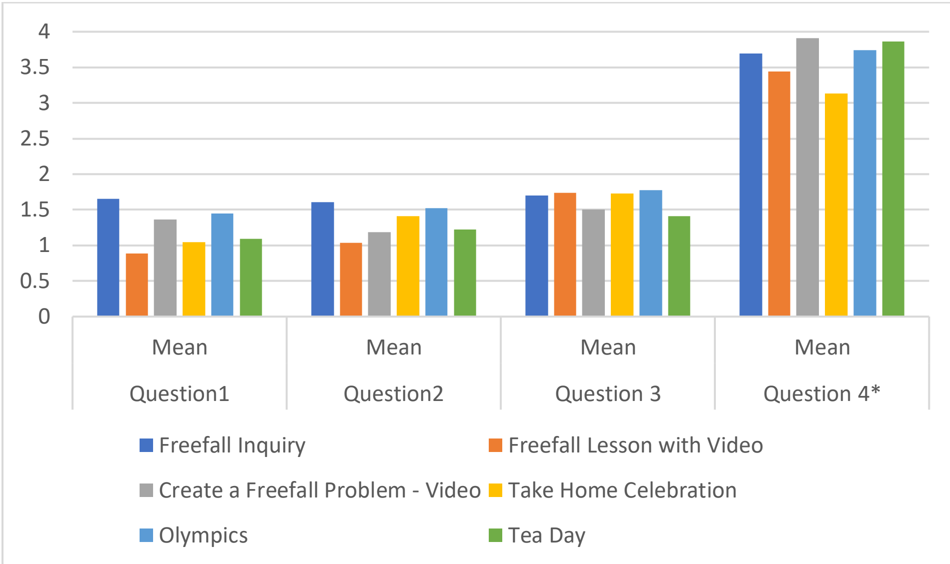
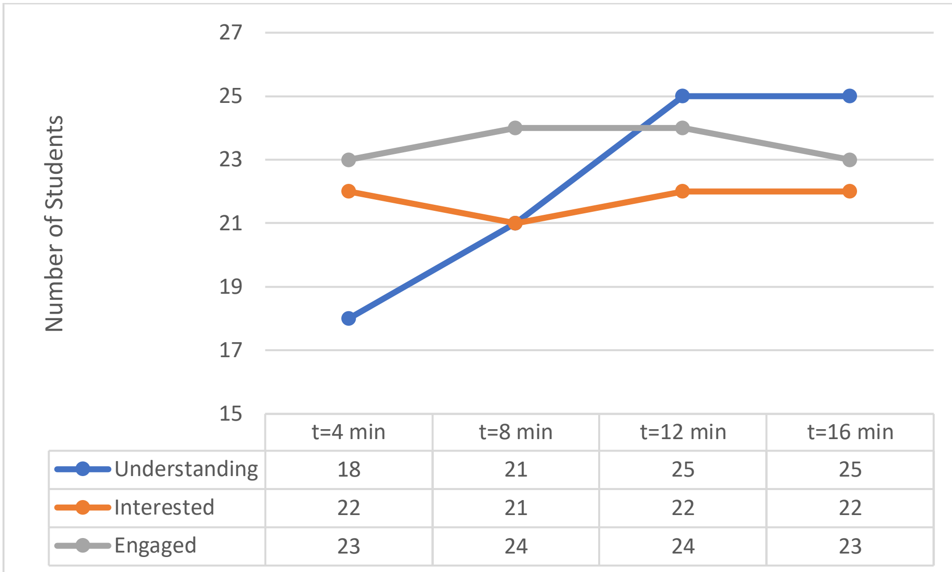


Figure 5. Mean values for student responses on questions 1-4 on post instrument exit slips (*question 4 was scored on a 1-5 point scale compared to a 0-2 point scale for questions 1-3).

Further data from the Freefall Inquiry (*n*=27) are stated below, show that student interested, and engagement stayed about the same over the 16 minutes that data was collected at 4-minute intervals (Figure 6). Student understanding increased from 18 to 27 students which is a 25% increase in the number of students understanding what they are trying to discover. This data supports the claim that small group and inquiry are beneficial for student engagement and understanding.



	t=4 min	t=8 min	t=12 min	t=16 min
Understanding	18	21	25	25
Interested	22	21	22	22
Engaged	23	24	24	23

Figure 6. Number of students understanding, interested, and engaged at 4 minute intervals during Freefall Inquiry.

Prior to treatments students were asked in the pre-treatment survey about what activities that had been completed in class thus far had been most beneficial to their ability to make connects of physic to their daily life (Figure 7). Most students (65%) said that the Physics Crash Course week at the beginning of the year which gave them an overview of the year was the most beneficial. Figure 8 show students ranking of the treatment activities in order of the most beneficial to least beneficial to making connections to their daily life. Overall, the Physics of the Olympic Seminar had the most first and second choice picks (57.7% of students), followed by Tea Day having 46.1% of students ranking this as a first or 2nd choice, and 38.6% ranked the Wisconsin Glacier Seminar as their first or 2nd choice. Of the first-choice options, the three seminars mention make up 80.8% of first choice, which supports that seminar days are beneficial to helping students make connection of physics content to their daily life.

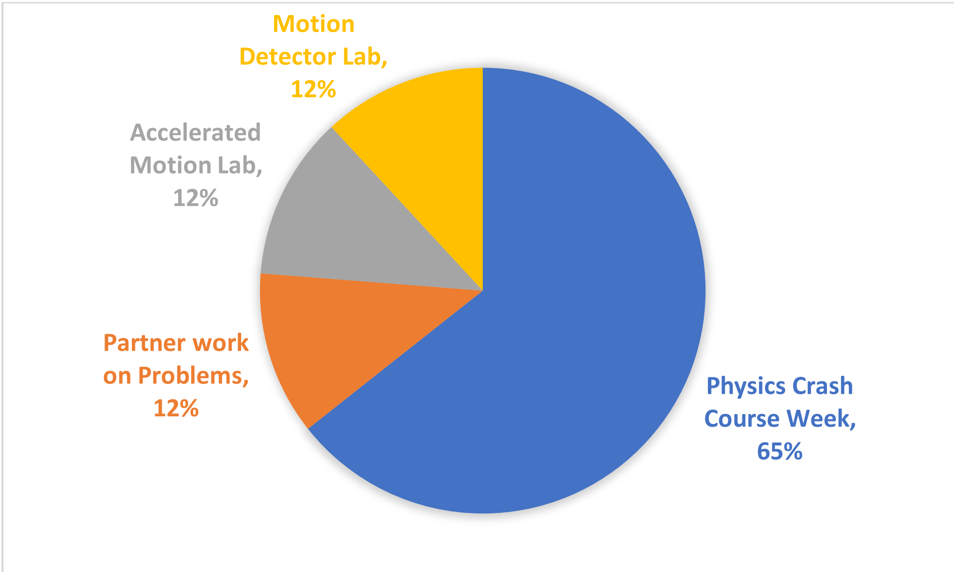
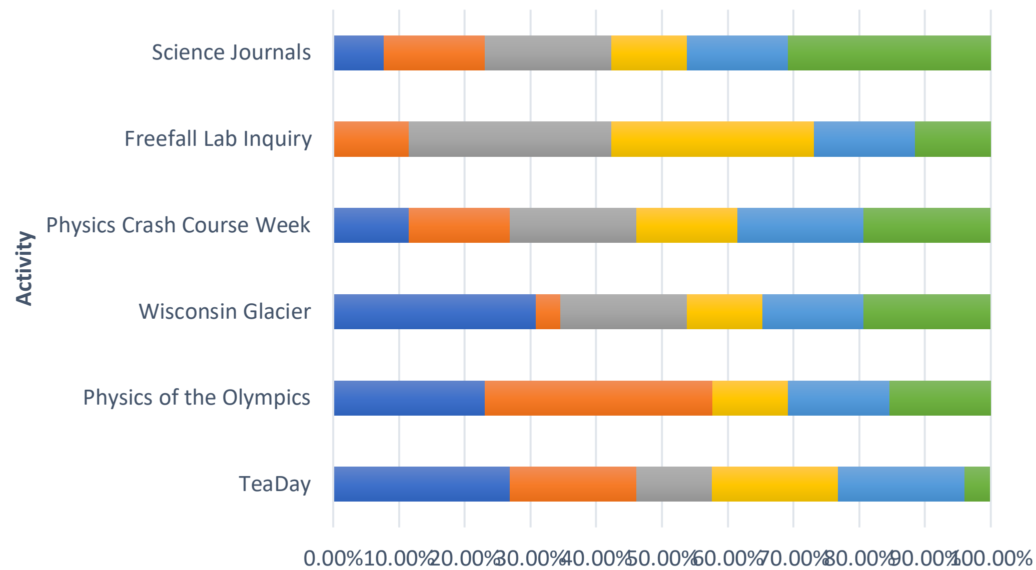


Figure 7. Pre-treatment student reflection on activities that best helped make connections about physics to their daily lives.



	TeaDay	Physics of the Olympics	Wisconsin Glacier	Physics Crash Course Week	Freefall Lab Inquiry	Science Journals
1st choice	26.90%	23.10%	30.80%	11.50%	0%	7.70%
2nd Choice	19.20%	34.60%	3.80%	15.40%	11.50%	15.40%
3rd Choice	11.50%	0%	19.20%	19.20%	30.80%	19.20%
4th Choice	19.20%	11.50%	11.50%	15.40%	30.80%	11.50%
5th Choice	19.20%	15.40%	15.40%	19.20%	15.40%	15.40%
6th Choice	3.80%	15.40%	19.20%	19.20%	11.50%	30.80%

Percent of Student Ranking

1st choice 2nd Choice 3rd Choice 4th Choice 5th Choice 6th Choice

Figure 8. Post treatment student reflection on activities that best helped make connections about physics to their daily lives.

During the beginning of the Force Unit, students constructed a motion concept map and then they were organized in to two groups. These groups separated the concept maps that included real world examples and ones that did not. Of the 28 students who completed the assignment, 13 students did not include real world examples and 15 students did include examples. When looking at the 13 students there were three students who had one to three real world examples, six students who had four to six real world examples and six students had seven or more real world examples.

Data Relating to Sub-Question #3

Students' science journal reflections, pre- and post-treatment surveys, and their Stream Science Journals were used to analyze how personal reflection effects student engagement. Students were asked in pre and post treatment surveys about how often they make connections to their daily lives outside of class. The results of the statistical analysis are shown in Table 5, which tells us that according to our paired t-test, there is no statistical evidence that supports the treatments changed student's frequency of making connections outside of the classroom.

Table 5. Statistics on Question 6 of the pre and post treatment survey.

Question 6. How often do you make connections of physics content to your daily life (outside the classroom)? 0 times 1-2 times 3-4 times 5 or more times*			
Question Statistics			
	Pre	*Post*	*Difference*
Mean	3.958	3.583	-0.375
Median	4	4	0
Mode	4	4	0
Standard Deviation	0.751	1.1	1.013

Hypothesis
µd= true mean difference in the post score - pre score
Ho - µd=0, no change
Ha - $\mu d \neq 0$
α=0.05

Paired T-test Results
t-stat = 0.464
p-value = 0.647
95% CI* = (-0.289, 0.455)
Because p-value is greater than alpha, we fail to reject Ho. There was not enough evidence to say that there is a difference in the post and pre scores.

*Note - Options were given numbers 1-4 to quantify data more easily. Selecting 0 times = 1, selecting 1-2 times = 2, selecting 3-4 times =3, and selecting 5 or more times = 4.

Upon investigating student scores on their Science Journal reflections of physics in their daily life, we can see a downward trend as the year went on (Figure 9). Which reflects that science journal reflections, does not necessarily positively effect student engagement. Figure 10 represents student scores when we take out the scores of students who did not complete the assignments, we can see from this altered data that scores do still drop off at the end however stay more consistent throughout the school year.

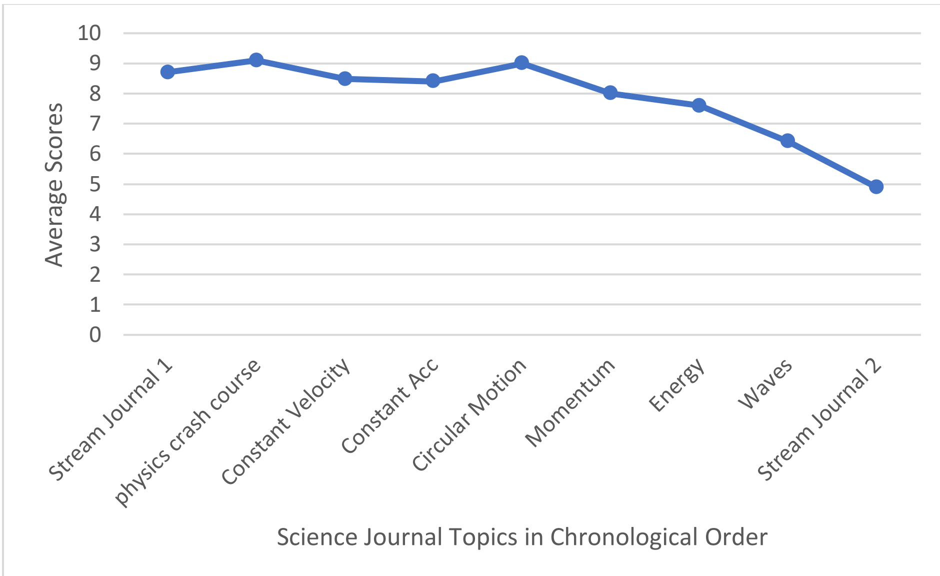


Figure 9. Average Scores on Science Journals, including scores of students who did not complete the assignment.

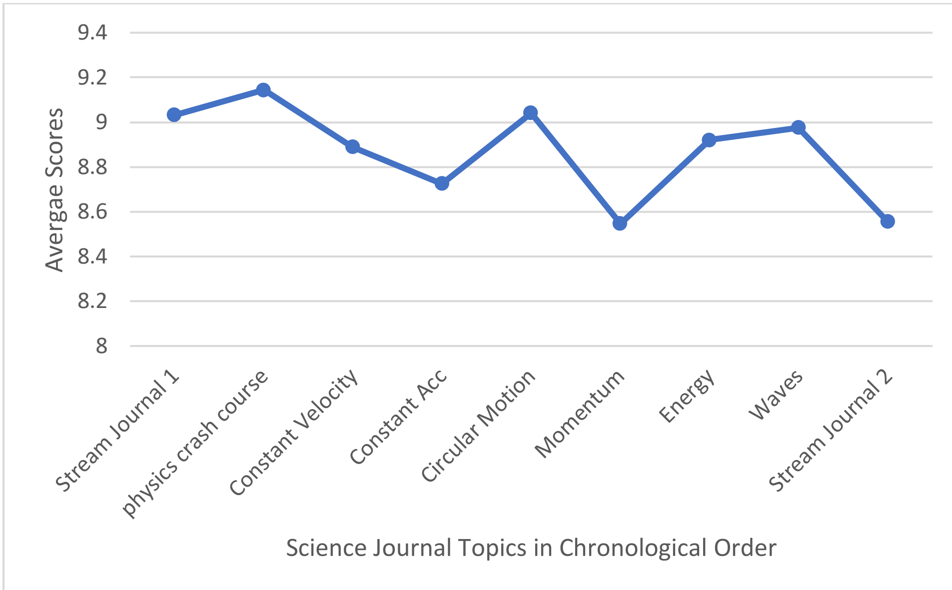


Figure 10. Average Scores on Science Journals, excluding scores of students who did not complete the assignment.

Despite student average scores and completion rate of science journals, when comparing the first science journal to the last science journal we can see an increase in connection made to physics and the real world. As well as an increase in physics vocabulary, see the two word clouds below as reference (Figure 11 & 12). Students completed a science journal based on a stream that they lived close to, looking at where they could see the physics in the stream. We can see from these two images that water and stream are the two most common words used in student reflection. We can also see in the second image that words like move, force, energy, interference, reflect, wave, and momentum are used more or were not used in student's first journal. Which supports that despite students' confidence in their ability to make connections with the real world decreasing, their ability to reflect and demonstrate their growth in knowledge over the course of the year has increased. One student wrote in the final Stream Science Journal, "Going back to this assignment a whole year later is so cool because you are able to see so much more physics now and it shows that you actually learned something this year (yay!)." Another student wrote, “It was interesting to see how much I have learned from first doing this assignment and actually knowing something about waves themselves…I am proud of how far I have come and how much better I actually got at physics because I was not the best first semester but now, I’m actually able to make some connections to real life.” Additionally, a student took videos of the stream taking approximately nine minutes to describe all of the physics they could see in the stream, specifically pointing out areas of the stream as they related to the content, we learned in class this year.

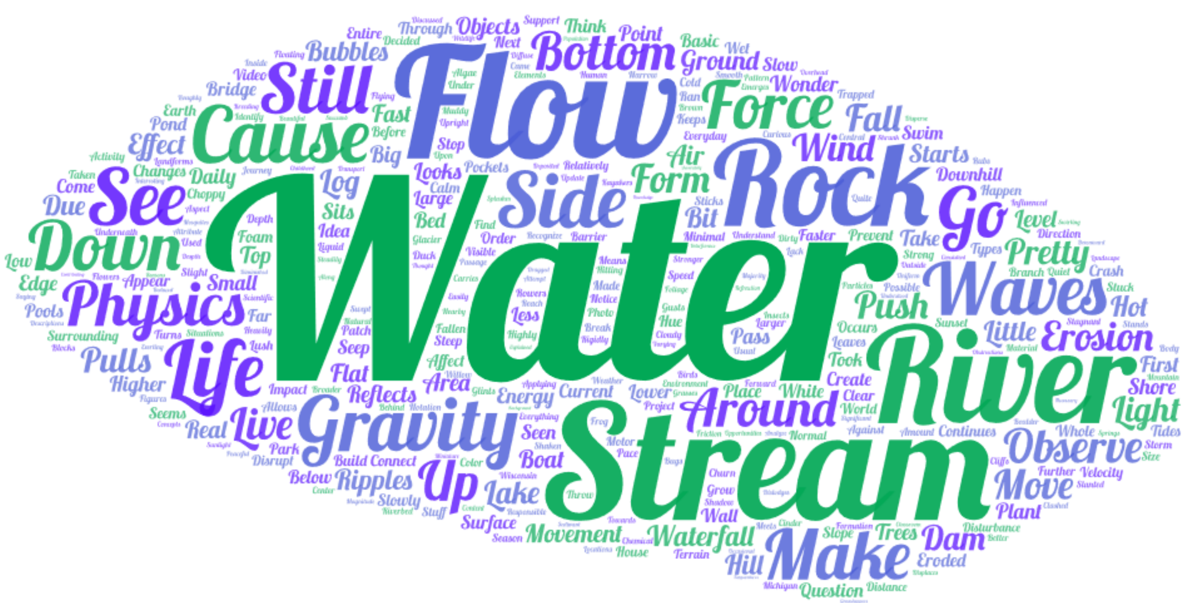


Figure 11. First Stream Journal Word Cloud.

Figure 12. Second Stream Journal Word Cloud.

CLAIM, EVIDENCE, & REASONING

Integration of physics into the everyday life of a high school student presents challenges because of the different experiences students have in their personal lives (connect to framework). Through this AR study, I have found that the use of real-world seminar days is extremely valuable to the engagement of students in the classroom. Seminar days help give students the opportunity to see and reflect on physics in their daily life. One student who had expressed frustration with physics throughout the year even came up to me after their senior trip to Six Flags and said, “Ms. Rio your glacier fieldtrip was better than senior trip.” And at graduation, the Valedictorian even mentioned the physics fieldtrips in reference to shared memories that the senior class has.

Through this study, I was able to determine inquiry activities and seminar days are valuable practices to student engagement. The use of real-world physics seminar days increased student engagement as shown by 85% of students ranking seminars as their first choice of activities, they found most engaging. Students also reflected that practice problems and labs/activities were the most beneficial to their learning in class. Neilsen (2008) found similarities after taking students to an amusement park in and making connection to the content they were learning in class. Neilson stated, “problem-solving activities from the field trip…enabled the students to develop deeper understandings of the kinematic concepts they encountered, enriching their prior conceptions” (Neilsen, 2008, p. 18).

While students found seminars to be engaging, my data demonstrates that the Physics of the Olympics Seminar Project, were the least engaging of the seminars. This could be because the project asked students to do many tasks from research, to analyzing in detail mathematically and conceptually, presenting, and creating a poster. Students’ performance on the project was very high showing many students deep understanding of the physics shown in the sport as well as their ability to research and calculate meaningful numbers to correctly model the physics at work. One group was able to calculate the speed of a ski jumper with and without friction based on the height and length of the ramp to very close accuracy of the true speed of the ski jumper at the end of the ramp. The project had many parts, and I would change that in future years to hopefully increase student engagement from where it was this year.

Incorporating seminar days and inquiry into the physics classroom were found to be the best practices seen in this study and help student make connections of physics to their everyday life as seen by students ranking these activities as their top choices. During these activities, students were engaged, actively participating as well as communicating with their peers using science vocabulary and problem solving together. Students continuously expressed their interest for these activities asking when the next seminar would be. Additionally, I could see how engaged students were and that they were having fun while learning in these different settings.

As a teacher I learned an incredible amount about my students, their interests, out of school activities, how they model work when given the freedom to choose. One student even found a video demonstrating how to use physics to adjust how they play tennis; this student is one of the best tennis athletes in our state. By incorporating physics into their personal interests, I found that students were more engaged. In addition, when students had a shared experience whether that was an inquiry activity or a seminar, they were able to make deeper connections to their daily life.

Student completion rate of science journal reflections and their confidence level decreased throughout the school year, however their quality of work and use of proper vocabulary while making connections to their daily life increased. It was found that personal reflection on physics in their personal lives does not appear to effect student engagement. Science Journal reflections showed a decrease in completion and scores. During the final two science journals completion rate among senior students drastically decreased, this is likely due to their impending graduation which could have affected the overall motivation. However, I would argue that despite this decrease these reflections are still valuable.

Other factors that may have effected the overall results of this study include, the timing of the post treatment survey could have affected student responses as it was completed during the last month of school, not including a control group, and an insufficient sample size for statistically significant results. The RWQ's on assessments were designed with the intention of asking students to apply their knowledge to a new real-world scenario, however the structure of the some of the questions did not lend themselves to provide much insight into their understanding of real-world factors. Despite this, students still demonstrated sufficient knowledge of physics in the real-world.

In collecting and interpreting quantitative and qualitative data, I was hoping to measure student engagement, best teaching practices, and use student reflection to gain a more in depth understanding of the most valuables tools to make connections of classroom content to the everyday lives of students. This study would most likely have similar results if carried out again, the student responses would vary, and their personal experience to connect classroom content to their lives would be different which may change how students respond to the instruments in this study. If this study were to be duplicated it would be challenging to interpret why the results were different due to the complexity of human interests and how they can personally connect to the classroom content. I feel that the findings will be able to be shared with my colleagues and would be valuable for them to see the importance of making connections of classroom content more relatable to the individual student.

Value of the Study and Consideration for Future Research

Value

This study was important because of the increased variety of strategies used, student feedback, and overall attitudes of students especially as it pertained to seminar days. Using a variety of teaching strategies was beneficial to students to allow them to use multiple ways of thinking and processing to better understand the content we were learning. Science Journals may have been too much for students, however there was value in seeing their grow as a teacher and many students also made observations of their own growth as they compared their work from the beginning of the year to the end of the year. Student feedback and seminar days were extremely insightful in not only their increased engagement in seminars, but also a mental health aspect that arose from these days. Students gave me feedback saying that the seminars were really helpful because it gave them a break from the mundane school day and many of the seminars and activities allowed them to be out of their desk and active in class. They were able to come back with renewed energy for learning concepts and it also allowed students to have a shared experience which in turn helped them make connections to physics in their daily lives as a group. This break from day-to-day classroom time as well as student reflection allowed me to get to know my students in a much different and more holistic way, which in turn was beneficial to student learning and engagement.

Consideration for Future Research

In the coming school years, I will continue to develop seminar days and investigate best assessment practices for making real-world connections, I also hope to begin a Summer Science Seminar class. During this past school year, I developed two additional seminar days which were not included in this research. These seminars were Physics of the Theater and Physics at the Lake Day. During Physics of the Theater, students spent a class period learning about the physics that occurs in the theater and behind the scenes, my colleague who is the technical director discussed different aspects of the structural design of the theater, and how sound and light play a role in a show. In the future, my colleague and I hope to further develop this seminar to have students investigate the laws of physics that go into building a set, flying different scenes on stage, and observing effects of light and sound in the theater.

I also desire to continue to research and learn about assessment practices that promote application of science content to everyday life. The assessment questions in this study were mostly short answer questions on final unit celebrations. When analyzing the data, I found that I was curious to know what other assessment practices could be more useful to demonstrate student learning.

In addition to keeping and adding in seminar days and look at assessment question I hope to develop a Summer Science Seminar class. This would include four to six days of lessons that would be designed to lead to a one or two week long trip during the summer. This would be a great continuation of the data from the use of seminar days from this research to investigate student engagement in a longer version of a seminar day.

Impact of Action Research on the Author

From this Action Research, I have been greatly impacted as a teacher and person. I have found that I am more creative than I give myself credit for and have been grateful for this project which encouraged my creative side. The creation of seminar days has been really engaging for myself and I have learned so much about physics in the world and now I look for it all the time so I can share what I learn with my students. Before taking my students on the Wisconsin Glaciation field trip, I did not know much about Wisconsin's Ice Age, so it was intriguing to learn for myself in order to share with my students. Another value I learned from the use of seminar days is that when I do not know all the answers to a concept it allows my students to become the investigators and the teachers which builds their interest and confidence in science. I also am very grateful for my students this year and realized that their science journal reflections gave me a better insight into who they are as people and learners. I was able to get to know all my students in a more holistic way, by seeing what their interests are and what they do outside of the academic day.

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APPENDICES

APPENDIX A

INTERNATIONAL REVIEW BOARD APPROVAL

MONTANA STATE UNIVERSITY
Request for Designation of Research as Exempt
MSSE Research Projects Only
(6/16/14)

****
THIS AREA IS FOR INSTITUTIONAL REVIEW BOARD USE ONLY. DO NOT WRITE IN THIS AREA.
Confirmation Date: 10/22/21 Mark T. Quinn
Application Number:
****

DATE of SUBMISSION:

-Okay as exempt
-MSSE classroom assessment
-Little/no risk
-Principal approved
-No concerns
MQ 10/22/21

Address each section – do not leave any section blank.

I. INVESTIGATOR:

Name: **Marissa Riordan**
Home or School Mailing Address: **16635 Norwood Ln. Brookfield, WI 53005**
Telephone Number: **(414) 803-6288**
E-Mail Address: **mari.riordan@gmail.com**
DATE TRAINING COMPLETED: **February 21, 2021** *[Required training: CITI training; see website for link]*

Investigator Signature **Marissa Riordan**

Name of Project Advisor: **Dr. Marcie Reuer**
E-Mail Address of Project Advisor: mreuer@montana.edu

II. TITLE OF RESEARCH PROJECT: **Physics of Everyday Life**

III. BRIEF DESCRIPTION OF RESEARCH METHODS (If using a survey/questionnaire, provide a copy).

In this research project, I will be implementing treatments to help students make connections from classroom content to their daily lives. This research will include surveys, small group work, seminar days and science journal entries. Assessments will include real-world problems some of which will be drawn from seminar experiences. These treatments will be carried out over the course of 2-3 units.

IV. RISKS AND INCONVENIENCES TO SUBJECTS:

Students will be missing class time for a field trip and will be asked to do a little more work than normal due to the student surveys and seminar days. Working in small groups, science journals, and surveys bring no risk to students, but may be challenged by these tasks.

V. SUBJECTS:

A. Expected numbers of subjects: 29

B. Will research involve minors (age <18 years)? **Yes** No

I am a high school physics teacher and students in my classes are 17 and 18 years old.

C. Will research involve prisoners? Yes **No**

D. Will research involve any specific ethnic, racial, religious, etc. groups of people?
(If 'Yes', please specify and justify.) Yes **No**

VI. FOR RESEARCH INVOLVING SURVEYS OR QUESTIONNAIRES:
(Be sure to indicate on each instrument, survey or questionnaire that participation is voluntary.)

A. Is information being collected about:

Sexual behavior?	Yes	**No**
Criminal behavior?	Yes	**No**
Alcohol or substance abuse?	Yes	**No**
Matters affecting employment?	Yes	**No**
Matters relating to civil litigation?	Yes	**No**

B. Will the information obtained be completely anonymous, with no identifying information linked to the responding subjects? **Yes** No

C. If identifying information will be linked to the responding subjects, how will the subjects be identified? (Please circle or bold your answers)

By name	Yes	**No**
By code	Yes	**No**
By other identifying information	Yes	**No**

D. Does this survey utilize a standardized and/or validated survey tool/questionnaire? **(If yes, see IRB website for <u>required wording</u> on surveys and questionnaires.**) Yes **No**

VII. FOR RESEARCH BEING CONDUCTED IN A CLASSROOM SETTING INVOLVING NORMAL EDUCATIONAL PRACTICES:

A. This research project must be approved by your Principal or School Administrator, unless there are circumstances or policies that do not make this possible. **Provide a copy of the principal's signed approval.** If such approval is not possible, please explain.

B. **Participation of your students in research must be voluntary** and can never affect their rights. Please make this issue clear on all of your research surveys (use introductory text, see below) and/or interviews (use introductory verbal statement, see below). The following wording or something similar can be used for the introductory text or statement: **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

C. Extra credit should not be used to encourage participation. If you absolutely need to use extra credit, then an alternative activity involving the same amount of time and effort must be provided for those who choose not to participate. This must be clearly described in your IRB application.

E. Depending on your school policies, **consent forms may or may not be required for your research.** Please indicate whether you will be using consent forms or not. If you are not using consent forms, please justify (e.g., school policy, etc.). **If you do use consent forms, you must include signature lines for parental consent AND student assent.** (Please use accepted format from our website and provide a stand-alone copy. Do not include form here.)

Instruments:

Introduction Survey
Participation in this survey is voluntary and participation or non-participation will not affect your grades or class standing in any way.

1. What concerns do you have about this class?
2. What are you most looking forward to learning about in this class?
3. What in class supports are the most helpful to your learning?
4. Please rank your preferences/comfortability for working with other students.
    a. Individually
    b. With one other person
    c. Small group (3 students, physically distant)
    d. No preference
5. Is there anyone in this class you cannot work with?
6. Tell me one good thing that you did this summer!

Survey #1 – Pre-Treatments

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

1. I am enjoying learning about physics.
    a. Strongly disagree
    b. Disagree
    c. It's okay.
    d. Agree
    e. Strongly disagree

2. Of the following activities we have completed in class, choose the one you felt was the **most engaging.**
    a. Physics Crash Course Week
    b. Motion Detector lab
    c. Accelerated motion lab
    d. Freefall Inquiry

3. Of the following activities we have completed in class, which best helped you **make connections** about physics to your daily life?
    a. Physics Crash Course Week
    b. Motion detector lab
    c. Accelerated Motion Lab
    d. Freefall Inquiry

For questions 4-6, five (5) is considered high and one (1) is considered low.

4. Rate your engagement in class so far.

    1 2 3 4 5

5. Rate your confidence level when it comes to making connections to physics in the real world.

1 2 3 4 5

6. Rate your engagement when working with small groups or a partner.

    1 2 3 4 5

7. Which of the following thing(s) have been the most helpful for your learning in class?
    a. Labs/activities
    b. Science journal reflections
    c. Lecture
    d. Practice problems
    e. Working with others

8. How often do you make connections of physics content to your daily life (outside the classroom)?
    a. 0 times a week
    b. 1-2 times a week
    c. 3-4 times a week
    d. 5 or more times a week
9. Describe the most interesting content you have learned so far in class.
10. What in class supports have been the most helpful to your learning?

Final Survey

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

1. I am enjoying learning about physics.
    a. Strongly disagree
    b. Disagree
    c. It's okay.
    d. Agree
    e. Strongly disagree

2. Of the following activities we have completed in class, choose the one you felt was the **most engaging.**
    a. Physics Crash Course Week
    b. Motion Detector lab
    c. Accelerated motion lab
    d. Freefall Inquiry
    e. Tea Day Seminar
    f. Wisconsin Ice Age Seminar

3. Of the following activities we have completed in class, which best helped you **make connections** about physics to your daily life?
    a. Physics Crash Course Week
    b. Motion detector lab
    c. Accelerated Motion Lab
    d. Freefall Inquiry

e. Tea Day Seminar
f. Wisconsin Ice Age Seminar

For questions 4-6, five (5) is considered high and one (1) is considered low.

4. Rate your engagement in class so far.

   1 2 3 4 5

5. Rate your confidence level when it comes to making connections to physics in the real world.

   1 2 3 4 5

6. Rate your engagement when working with small groups or a partner.

   1 2 3 4 5

7. Which of the following thing(s) have been the most helpful for your learning in class?
   a. Labs/activities
   b. Science journal reflections
   c. Lecture
   d. Practice problems
   e. Working with others
   f. Seminar days

8. How often do you make connections of physics content to your daily life (outside the classroom)?
   a. 0 times a week
   b. 1-2 times a week
   c. 3-4 times a week
   d. 5 or more times a week
9. Describe the most interesting content you have learned so far in class.
10. What in class supports have been the most helpful to your learning?

Administrator Approval

I, Edward Foy, Principal of Dominican High School, verify that I approve of the classroom research conducted by Marissa Riordan.

____

Edward Foy, Principal

EDWARD Foy

Printed Name

10/13/2021

Date

Administrator Exemption Regarding Informed Consent

I, Edward Foy, Principal of Dominican High School, verify that the classroom research conducted by Marissa Riordan is in accordance with established or commonly accepted educational settings involving normal educational practices and that I approve the project. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Marissa Riordan regarding informed consent.

____

Edward Foy, Principal

Edward Foy

Printed Name

10/13/2021

Date

APPENDIX B

PRE TREATMENT SURVEY

Pre Treatment Survey

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

1. Please answer the question below, using the given scale.

   I am enjoying physics.

   Strongly disagree Disagree It's Okay. Agree Strongly Agree

2. Of the following activities we have completed in class, choose the one you felt was the **most engaging**.
   a. Physics Crash Course Week
   b. Motion Detector Lab
   c. Accelerated Motion Lab
   d. Partner work on problems

!

3. Of the following activities we have completed in class, which best helped you **make connections** about physics to your daily life?
   a. Physics Crash Course Week
   b. Motion Detector Lab
   c. Accelerated Motion Lab
   d. Partner work on problems

4. For the following questions, five (5) is considered high and one (1) is considered low.

   Rate your engagement in class so far.
   1 2 3 4 5
   Rate your confidence level when it comes to making connections to physics in the real world.
   1 2 3 4 5
   Rate your engagement when working with small groups or a partner.
   1 2 3 4 5

5. Which of the following thing(s) have been the most helpful for your learning in class?
   a. labs/activities
   b. Science Journal Reflections
   c. Lecture
   d. Practice Problems
   e. Working with others

6. How often do you make connections of physics content to your daily life (outside the classroom)?
    a. 0 times a week
    b. 1-2 times a week
    c. 3-4 times a week
    d. 5 or more times a week

7. Describe the most interesting content you have learned so far in class.

8. What in class supports have been the most helpful to your learning? Explain.
   For example: lecture, videos, pictures, activities, homework, group work, etc.

APPENDIX C

FREEFALL INQUIRY ACTIVITY MATERIALS AND EXIT SLIP

Freefall Investigation Inquiry Rubric.

	4	3	2	1
Investigation – Process, recording of observations, sharing	Investigation process and observations were fully recorded, organized, and claims were mostly accurate	Investigation process and observations were recorded, organized, and claims were somewhat accurate	Investigation process and observations were partially recorded, organized, and claims were somewhat accurate	Investigation process and observations were not recorded, organized, and claims were not made
CER from videos	Claims and evidence were provided with detailed reasoning and thorough explanation	Claims and evidence were provided with reasoning and explanation	Claims and evidence were minimal with little reasoning and explanation	Claims and evidence were not given
Engagement	Fully engaged in the activity and trying to get the most out of it	Mostly engaged in activity and tried to get something out of it	Little engagement in activity, not trying to getting something out of it	Little to no engagement in activity.
Small group/Partners	Partner(s) were beneficial to the engagement of the activity	Partner(s) were somewhat beneficial to the engagement of activity	Partner(s) were only a little beneficial to the engagement of the activity	Partner(s) were not beneficial to the engagement of the activity

Freefall Exit Slip

1. What is the most important take away from today's lesson?

2. What content can you take from today and connect to the real world and your daily life?

3. Who/what might actually use this in their day to day life?

4. On the scale below rate the lesson.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful were the videos/images/drawings to your engagement in class today? Rate and explain.

Low High
1 2 3 4 5

Freefall Exit Slip

1. What is the most important take away from today's lesson?

2. What content can you take from today and connect to the real world?

3. Who/what might actually use this in their day to day life?

4. On the scale below rate the lesson.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful were the videos/images/drawings to your engagement in class today? Rate and explain.

Low High
1 2 3 4 5

I am understanding/not understanding this activity.

I am interested/not interested in what is happening.

I am engaged/not engaged in this activity.

I am understanding/not understanding this activity.

I am interested/not interested in what is happening.

I am engaged/not engaged in this activity.

I am understanding/not understanding this activity.

I am interested/not interested in what is happening.

I am engaged/not engaged in this activity.

I am understanding/not understanding this activity.

I am interested/not interested in what is happening.

I am engaged/not engaged in this activity.

I am understanding/not understanding this activity.

I am interested/not interested in what is happening.

I am engaged/not engaged in this activity.

APPENDIX D

FREEFALL LECTURE WITH VIDEO DESCRIPTION AND EXIT SLIP

Freefall Lecture

Background Information

- Notes on Freefall concepts were taken, and ideas were generated from the freefall activity.
- Acceleration due to gravity constant was recorded and real-world factors that effect objects in freefall were listed

This lesson came after an introduction to Freefall and Freefall Inquiry Activity. After students make their models and discuss their ideas, to further develop how the factors of air resistance and surface area effect falling objects, the following videos can be watched and students will evaluate their understanding of gravity in the real world, where factors like air resistance and surface area are not ignored.

For each video listed below, students will write a CER about how gravity and real-world factors play a role in these new phenomena drawing from their activity and our discussion.

- Hammer vs. Feather – Physics on the Moon - https://www.youtube.com/watch?v=KDp1tiUsZw8
- Flying Squirrel – https://www.youtube.com/watch?v=NR4JYGUdbWE
- Soaring Golden Eagle – https://www.youtube.com/watch?v=azQJKhN1yNs
- Flying Squirrel Suits - https://www.tetongravity.com/video/adventure/squirrel-wingsuit-pilots-defy-gravity-and-fly-up

Freefall Lecture Exit Slip

1. What is the most important take away from today's lesson?
2. What content can you take from today and connect to the real world and your daily life?
3. Who/what might actually use this in their day to day life?
4. On the scale below rate the lesson.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful were the videos/images/drawings to your engagement in class today? Rate and explain.

Low High
1 2 3 4 5

Freefall Lecture Exit Slip

1. What is the most important take away from today's lesson?
2. What content can you take from today and connect to the real world?
3. Who/what might actually use this in their day to day life?
4. On the scale below rate the lesson.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful were the videos/images/drawings to your engagement in class today? Rate and explain.

Low High
1 2 3 4 5

APPENDIX E

CREATE A FREEFALL PROBLEM ACTIVITY MATERIALS

Projectile Video Activity

You and a partner are creating a projectile motion video and a problem that will explain the motion of the object in your video. Your task will be to determine the initial velocity of the object in your problem to the best of your ability, you will have to take some measurements. When you complete the video and problem, be sure to explain your process. This could be in a video, an audio file, or written out. All of this information will need to be put into a OneNote page in the Science Journal section.

Problem	Video
Graphs – with labels [3] Accuracy of problem [5] • Showing your work (3) • Significant figures (1) • Units (1) Organization of work [3] Deriving Equations that represent motion [6] • Horizontal position • Vertical position Grammar [2]	Quality of Video(s) [2] Originality [3] Portrayal of problem [3] Explanation of Problem [5] • How did you solve it? What could effect your numbers?

Total Points: 32

Post- Create Your Own Freefall Problem Exit Slip

1. What is the most important take away from today's activity?

2. What content can you take from today and connect to the real world and your daily life?

3. Who/what might actually use this in their day to day life?

4. On the scale below rate the activity.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful was creating your own problem and video to your engagement in class today? Rate and explain.

Low High
1 2 3 4 5

Post- Create Your Own Freefall Problem Exit Slip

1. What is the most important take away from today's activity?

2. What content can you take from today and connect to the real world and your daily life?

3. Who/what might actually use this in their day to day life?

4. On the scale below rate the activity.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful was creating your own problem and video to your engagement in class today? Rate and explain.

Low High
1 2 3 4 5

APPENDIX F

POST CELEBRATION TAKE HOME EXIT SLIP

Post- Take Home Celebration Exit Slip

1. What is the most important take away from the take home celebration?

2. What content can you take from the celebration and connect to the real world and your daily life?

3. Who/what might actually use this in their day to day life?

4. On the scale below rate the celebration.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful was the take home celebration to your engagement to classroom content? Rate and explain.

Low High
1 2 3 4 5

Post- Take Home Celebration Exit Slip

1. What is the most important take away from the take home celebration?

2. What content can you take from the celebration and connect to the real world and your daily life?

3. Who/what might actually use this in their day to day life?

4. On the scale below rate the celebration.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful was the take home celebration to your engagement in class content? Rate and explain.

Low High
1 2 3 4 5

APPENDIX G

ASSESSMENT QUESTIONS

Assessment Questions

Freefall Unit Celebration Questions

1. A rock is dropped at the same instant that a ball, at the same initial elevation, is thrown horizontally. Which will have a greater velocity when it reaches ground level? Explain. (Air resistance is so small it can be ignored.)

2. In one scene of a Bugs Bunny cartoon, we find bugs standing on a flat rock as both he and the rock fall through the air under gravity. Just before impact with the ground, Bugs Bunny steps off the rock and walks away, completely unharmed; the rock is totally destroyed. Why is this scene unrealistic? What is a more realistic fate for bugs?

3. The following objects are dropped from the same height and air resistance is not ignored. Compare the motion of these objects as they fall to the ground, **explain your reasoning**.

   Objects: a glass plate, a plate paper plate, and an apple.

Freefall Final Questions

1. A student at the top of a building of height age throws one ball upward with an initial velocity, and then throws a second identical ball downward the same initial speed. How do the final velocities of the balls compare when they reach the ground? **Explain your reasoning**.

2. The following objects are dropped from the same height and air is instance is not ignored.

   Objects: a physics textbook, a piece of paper, and a 15 lbs bowling ball. Assume the textbook and piece of paper have identical surface areas.

   a. Compare the motion of these objects as they fall to the ground, explain your reasoning.
   b. Explain a possible plausible way to have the piece of paper reach the ground at a similar time to the bowling ball.

Wisconsin Glacier Question

1. Even an example of how Wisconsin landscape was formed by glaciers and how it specifically relates to physics (think forces and motion).

Energy Unit Celebration Questions

1. An advertisement for a bouncy ball states that the ball will rebound to a height greater than the height from which it is dropped. Is this possible? Explain your answer.

Tea Day Questions

1. In detail, explain the process of sloshing in a tea cup and at least one possible solution to counter act this phenomenon.

2. Answer the following questions about patterns seen in tea day that can be seen in other parts of the world.
    a. Describe the pattern of milk and tea mixing together AND how it relates to other patterns we can see in the world.
    b. Describe the pattern of boiling water to make tea AND how it relates to other patterns we can see in the world.

Energy Final Exam Questions

1. If Peter were to take over Dominican and climb to the top of the school to announce his triumph (initial condition), and then proceed to jump off the building to north campus. Explain the conservation of energy theorem as it relates to this situation. (No Peter's were hurt in this example.)

Physics in Everyday Life Final Exam Questions

1. Pick two of the following topics and explain a specific example of how the physics topic relates to your everyday life.
    a. Momentum
    b. Energy
    c. Waves

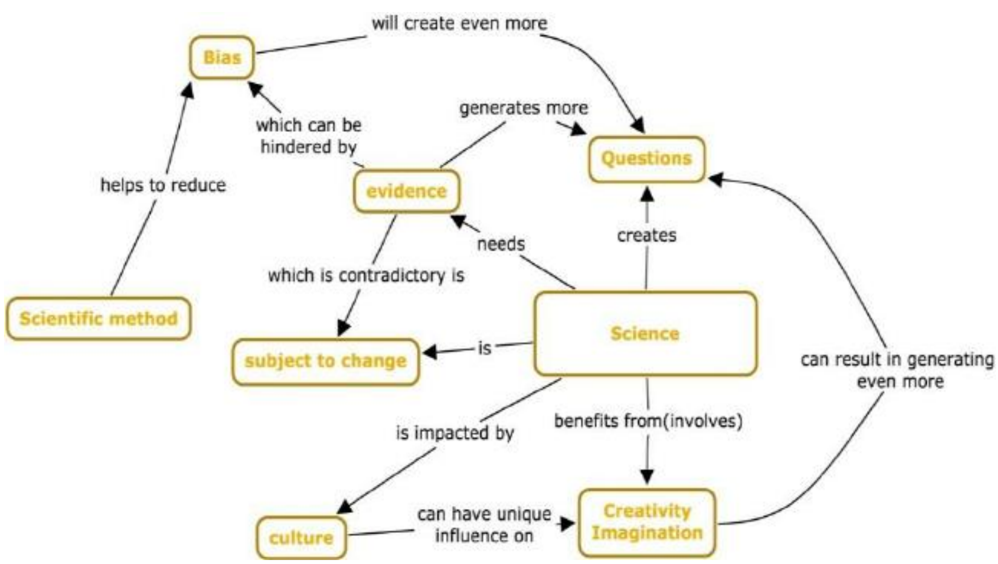
APPENDIX H

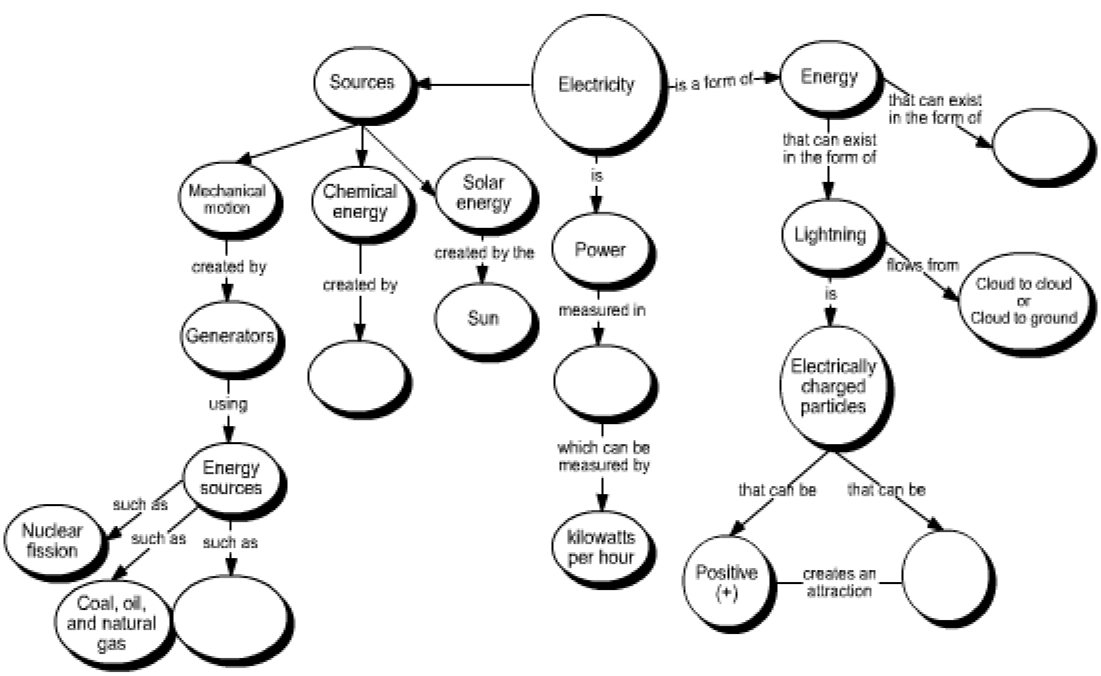
CONCEPT MAP EXPLANATION

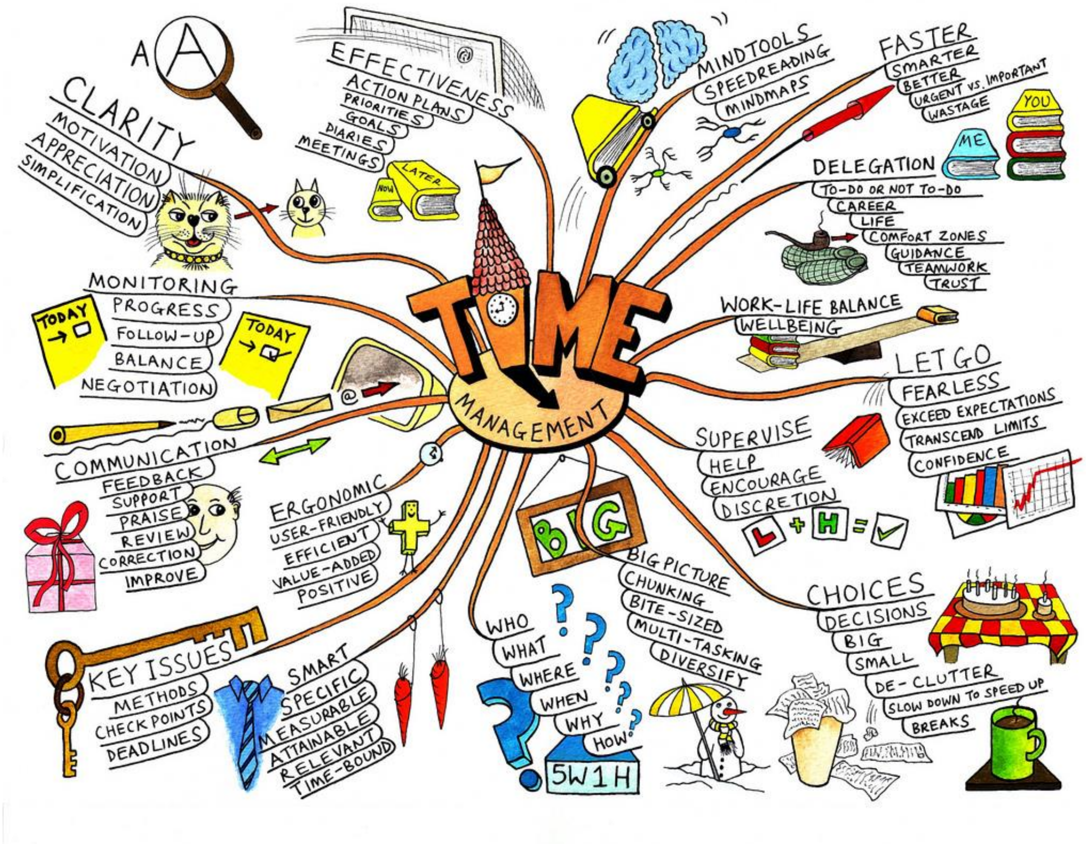
Concept Map Activity

Today we will be creating a concept map about **motion**. We will start by looking at the different concepts that relate to motion. Then we will break down those concepts into more specific section as well as add examples. You can design your concept map however you want, there should be "bubbles" around main ideas/concepts and words connecting the ideas and concepts. There should be many connections between the ideas and concepts.

Here is an example below to give you an idea of what you can do!





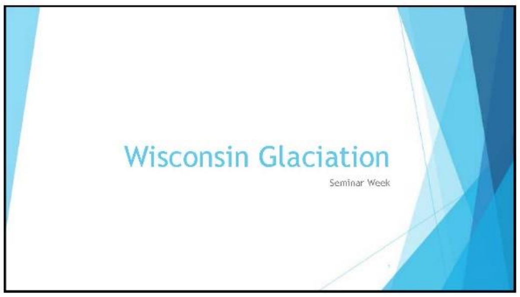

TIME
MANAGEMENT
CLARITY
MOTIVATION
APPRECIATION
SIMPLIFICATION
EFFECTIVENESS
ACTION PLANS
PRIORITIES
GOALS
DIARIES
MEETINGS
MINDTOOLS
SPEEDREADING
MINDMAPS
FASTER
SMARTER
BETTER
URGENT VS. IMPORTANT
WASTAGE
YOU
ME
DELEGATION
TO-DO OR NOT TO-DO
CAREER
LIFE
COMFORT ZONES
GUIDANCE
TEAMWORK
TRUST
MONITORING
PROGRESS
FOLLOW-UP
BALANCE
NEGOTIATION
TODAY
WORK-LIFE BALANCE
WELLBEING
LET GO
FEARLESS
EXCEED EXPECTATIONS
TRANSCEND LIMITS
CONFIDENCE
COMMUNICATION
FEEDBACK
SUPPORT
PRAISE
REVIEW
CORRECTION
IMPROVE
ERGONOMIC
USER-FRIENDLY
EFFICIENT
VALUE-ADDED
POSITIVE
SUPERVISE
HELP
ENCOURAGE
DISCRETION
BIG
BIG PICTURE
CHUNKING
BITE-SIZED
MULTI-TASKING
DIVERSIFY
CHOICES
DECISIONS
BIG
SMALL
DE-CLUTTER
SLOW DOWN TO SPEED UP
BREAKS
KEY ISSUES
METHODS
CHECK POINTS
DEADLINES
SMART
SPECIFIC
MEASURABLE
ATTAINABLE
RELEVANT
TIME-BOUND
WHO
WHAT
WHERE
WHEN
WHY
HOW
5W1H

APPENDIX I

WISCONSIN GLACIATION SEMINAR WORKSHEET, REFELCTION & EXIT SLIP

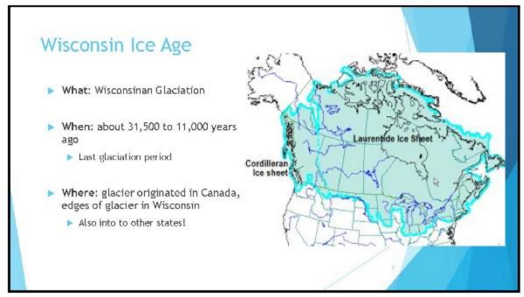
Wisconsin Glaciation – Kettle Moraine State Park Fieldtrip Worksheet

Stop #1 – Visitor Center - What did glaciers transport to Wisconsin? - What type of moraine is the Kettle Moraine? - What are striations? What do they tell us? - What can you learn about glaciers around the world? - What other parts of the state are essential to understand the geographical history of Wisconsin? Explain. - Any other points of interest to you?	**Stop #2 – Dundee Mountain** - What glacial formation is Dundee Mountain? How was it formed? - What other glacial formations can you see? How were they formed?
Stop #3 – Parnell Observation Tower - What glacial formations can you see at the tower and on the trail?	**Observations & Connections to Physics**



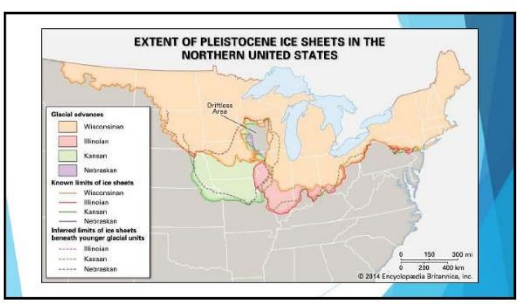
Wisconsin Glaciation
Seminar Week

1



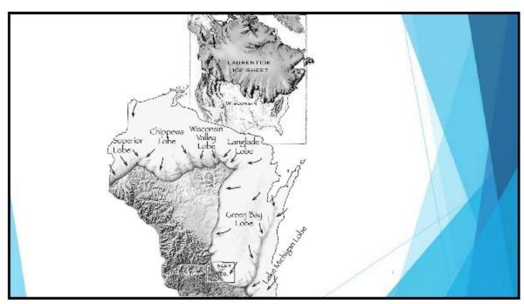
Wisconsin Ice Age
What: Wisconsinan Glaciation
When: about 31,500 to 11,000 years ago
Last glaciation period
Where: glacier originated in Canada, edges of glacier in Wisconsin
Also into to other states!
Laurentide Ice Sheet
Cordilleran Ice sheet

2



EXTENT OF PLEISTOCENE ICE SHEETS IN THE NORTHERN UNITED STATES
Driftless Area
Glacial advances
Wisconsinan
Illinoian
Kansan
Nebraskan
Known limits of ice sheets
Wisconsinan
Illinoian
Kansan
Nebraskan
Inferred limits of ice sheets beneath younger glacial units
Illinoian
Kansan
Nebraskan
0 150 300 mi
0 200 400 km
© 2014 Encyclopædia Britannica, Inc.

3



LAURENTIDE ICE SHEET
Superior Lobe
Chippewa Lobe
Wisconsin Valley Lobe
Langlade Lobe
Green Bay Lobe
Lake Michigan Lobe

4

Glaciers

- French word for ice → ***glace***
- "Rivers of Ice"
- How do glaciers form?
  - Snow fall > snow melt
- Alpine glaciers vs. Ice sheets

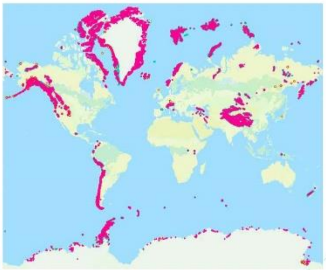
5

Glaciers continued…

- What does the name "Rivers of Ice" imply?
  - Motion!
- How do glaciers move?!
  - "Deformation of the ice itself" (NPS)
    - Microscopic – ice crystals breaking and reforming
  - "motion at the glacier base" (NPS)
    - Flow over earth below → water

6

7



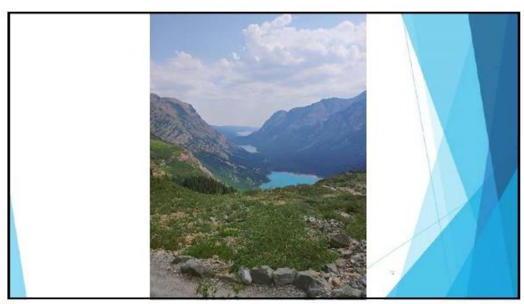
Glaciers around the world - National Snow and Ice Data Center

8

9

10

11

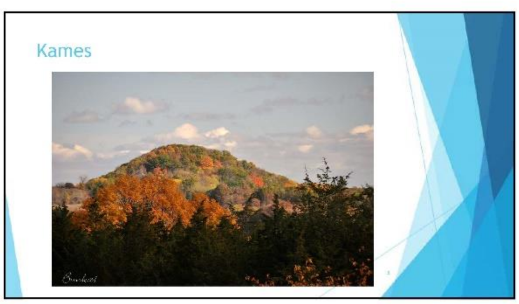


12

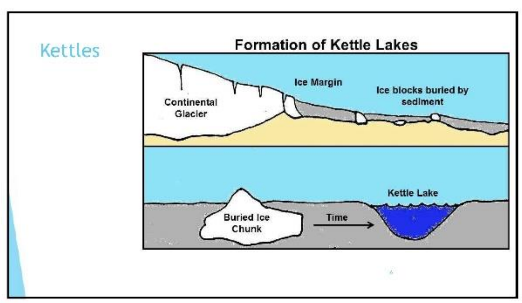
13


Great Lakes

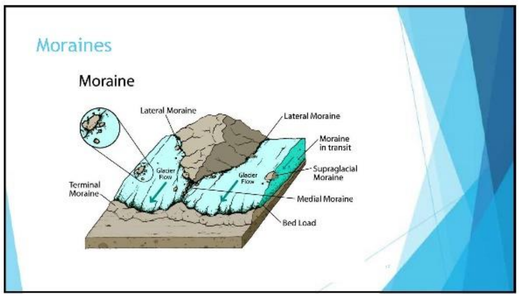
14


Kames

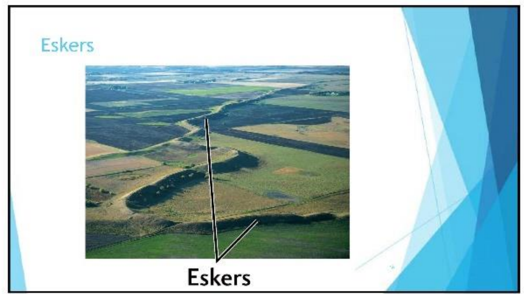
15


Kettles
Formation of Kettle Lakes
Continental Glacier
Ice Margin
Ice blocks buried by sediment
Kettle Lake
Buried Ice Chunk
Time

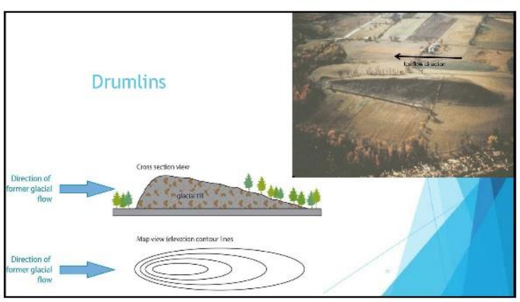
16


Moraines
Moraine
Lateral Moraine
Lateral Moraine
Moraine in transit
Glacier Flow
Glacier Flow
Supraglacial Moraine
Terminal Moraine
Medial Moraine
Bed Load

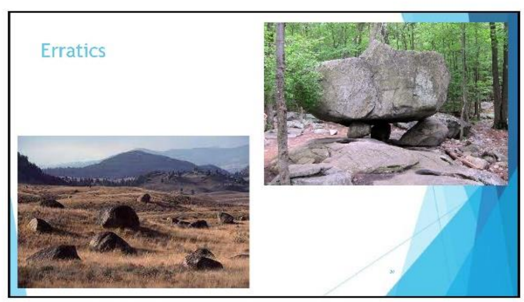
17


Eskers
Eskers

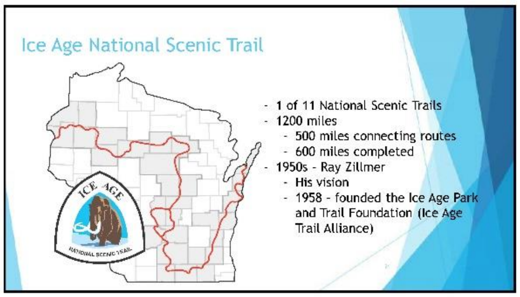
18


Drumlins
Cross section view
Direction of former glacial flow
glacial till
Map view (elevation contour lines)
Direction of former glacial flow

19


Erratics

20



Ice Age National Scenic Trail
ICE AGE
NATIONAL SCENIC TRAIL
- 1 of 11 National Scenic Trails
- 1200 miles
- 500 miles connecting routes
- 600 miles completed
- 1950s - Ray Zillmer
- His vision
- 1958 - founded the Ice Age Park and Trail Foundation (Ice Age Trail Alliance)

21

Background Vocabulary List & Background Information

Define the following words - Pictures will be helpful to understand the term! It may be helpful to type in geology after the term.

- Glacier
- Geology formation
- Drift and driftless area
- Sediment
    - "Types" of Sediment
        - Silt
        - Colluvium
        - Alluvium
        - till
        - Outwash
- Sediment structures
    - Bedding
    - Metamorphic rock
- Glacier formations
    - Moraine
    - Lateral moraine
    - Terminal/end moraine
    - Erratic
    - Hummocky terrain
    - Eskers
    - Kame
    - Kettle
    - Drumlins

More background information

- The Importance of Glaciers to Wisconsin - https://www.schlitzaudubon.org/2019/01/15/the-importance-of-glaciers-to-wisconsin/
- Glaciers and Glacial Landforms - https://www.nps.gov/subjects/geology/glacial-landforms.htm
- How Glaciers Move - https://www.nps.gov/articles/howglaciersmove.htm
- National Geographic Glacier Resource Page - https://www.nationalgeographic.org/encyclopedia/glacier/
- Ice Age Geology - https://wgnhs.wisc.edu/wisconsin-geology/ice-age/
- Glaciers: Things to Know - https://www.usgs.gov/special-topic/water-science-school/science/glaciers-things-know?qt-science_center_objects=0#qt-science_center_objects
- Facts about Glaciers - https://nsidc.org/cryosphere/glaciers/quickfacts.html
- Glacier Power: How Glaciers Move? https://asf.alaska.edu/information/glacier-power/glacier-power-how-do-glaciers-move/

How quickly do glaciers travel?

by How It Works Team· 11/04/2012

The speed of glaciers varies greatly depending on ice thickness, temperature, slope,

snowfall and the presence of meltwater at the contact point between the ice bottom and the land underneath. Some glaciers do not move at all. Many move at a rate between zero and about half a kilometre (0.3 miles) per year.

The fastest moving glacier is in Greenland, rushing forward at 12.6 kilometres (7.8 miles) per year. The middle of a glacier moves much more quickly than its edges, which are held back by friction with the surrounding land. Large objects frozen in the ice may get stretched apart because of this different rate of movement.

Answered by: Dr Richard Hebda, curator of Botany and Earth History

Kettle Moraine State Park – Science Journal Template and Exit Slip

Title - Kettle Moraine Field Trip

Date: ____________________

Location: _________________

Time: ____________________

Content

- Reflect on the content of the week.
  - What are we learning about?
  - Include vocabulary

Observations

Observations from our fieldtrip, could be a good place to put in pictures and makes notes about them and what you can see in them!

- What did you observe?
- Where is the physics?
- Can you make connections this weeks content to your daily life?
- Include vocabulary

Images/Drawings (With Color)

- These can be in a separate "section" or they can be within the observation and content sections. Images should be described.

Reflection

- What questions do you still have from this week?
- Explain what could you have done better and what worked well for you this week.
- Other thoughts or reflections…

Self Grading Based on Rubric Below

- Rubric - Explain your reasoning for the grade you give yourself!

4	3	2	1	0
All standards met and exceeded	All standards met	1-2 standards not met	3+ standards not met	Incomplete

- Standards for your science journal include having all of the above listed content. Not all sections need to be in paragraph form, they can include pictures, concept maps, notes, drawings, etc.

Questions

Please answer the following questions as part of your science journal reflection.

1. Rate your engagement on the following two things (1 is low, 5 is high):
    1. The content of the week.

1	2	3	4	5

    2. The field trip itself.

1	2	3	4	5

2. Explain your ratings for question #1.
3. Mr. Foy would like to you to write a statement to argue for or against this field trip happening in future years. Write a short paragraph with evidence and convincing arguments to persuade Mr. Foy to keep or cancel the trip.
4. Ms. Riordan is interested in how to make this seminar week better for the next time. Please specifically describe ways that would help make this past week more engaging for students.

APPENDIX J

WINTER OLYMPICS PROJECT INFORMATION AND RUBRIC

Content

- Background information
    - History of the sport
    - Summary of the rules of the sport
    - Variations of competition

- Physics Content
    - Using what we have learned in class and outside resources analyze the physics of the Olympic sport. Describe and analyze in detail the sport including the following topics:
        - Describe motion in detail using vocabulary from class
        - Explain the forces acting on the athletes, identify types used in class
        - Analyze the momentum and energy as it relates to the sport

- Media
    - Video analysis
        - Pick two of the same sport but different athletes/variations of competition
        - Conceptually and mathematically analyze the videos.
- Visual
    - Poster – summarizing your analysis
        - Digital or paper
    - Images, Physics content knowledge, NGSS

Video Analysis				
	10-8	**7-5**	**4-3**	**2-0**
Content - Conceptual	Ideas carefully explained, makes sense	Ideas explained, mostly makes sense	Ideas explained	Ideas not explained
Content - Mathematical	Ideas carefully explained, makes sense	Ideas explained, mostly makes sense	Ideas explained	Ideas not explained
Demonstrating Knowledge	Knowledge of what we have learned in class is demonstrated.	Some of what we have learned in class is demonstrated, with some explanation.	Some knowledge of what we have learned in class is noted, but understanding is not shown.	Little to no knowledge demonstrated.
Format & Organization	Content is very well expressed and organized – presentation is fluid	Well expressed and organized – presentation is occasionally fluid	Not organized well – difficult to understand at times	Not organized/formatted, difficult to understand

Poster				
	10-8	**7-5**	**4-3**	**2-0**
Visual – Layout	Images and words are esthetically pleasing and organized – clean and neat	Images and words are organized - clean and neat	Images and words are on the poster- not organized, clean and neat	Not enough images and words are on the poster- not organized, clean and neat
Presentation of Information	Analysis is shared in enough detail to be understood, and not too much to be overwhelming	Analysis is shared in some detail and/or it is overwhelming	Analysis is shared with limited detail	Little to no analysis is shared
		5-4	**3-2**	**1-0**
Grammar/English		Text/language in proper English – no to few errors in capitalizations, punctuation, usage, and spelling	Somewhat proper English – frequent to many errors in capitalizations, punctuation, usage, grammar, and spelling	Numerous errors, making presentation difficult to understand
Check in with Ms. Rio – Think of this as your rough draft		All check ins on time with well thought out and designed plan.	Some check ins on time with well thought out and designed plan.	Did not check in or have a well thought out plan or work to show.
Turned in on Time				2 – Project submitted to me the day before your presentation 0 – Project was not submitted the day before your presentation.

Presentation				
	10-8	**7-5**	**4-3**	**2-0**
Content	Physics content is explained thoroughly, in great detail.	Physics content is explained, in some detail.	Physics content is partially explained, in little detail.	Physics content is partially explained.
Delivery – Volume & Rate	Words are spoken loudly, clearly, and slowly.	Words are spoken somewhat loudly, clearly and slowly.	Words are not spoken loudly, clearly and slowly.	Words are not spoken loudly, clearly and slowly - challenging to understand.
Delivery – audience Connection	Content is delivered with confidence and composure; good eye contact is made and not dependent on notes.	Content is delivered with some confidence and composure; some eye contact is made and/or somewhat dependent on notes.	Content is delivered with little confidence and composure; little eye contact is made and/or mostly dependent on notes.	Content is delivered with little to no confidence or composure; little to no eye contact is made and/or presentation is read from notes.
Organization	Content is delivered in an organized format that helps the audience understand the content. Sequence of presentation is clear and fluid.	Content is delivered in a somewhat organized format that helps the audience understand the content. Sequence of presentation is mostly clear and fluid.	Content is delivered with little organization or is hard for the audience to understand the content. Sequence of presentation is not clear and/or fluid.	Content is delivered with little to no organization and is hard for the audience to understand the content. Sequence of presentation is not clear or fluid.
Length of Presentation				2 – meets length requirements 0 – does not meet length requirements

APPENDIX K

TEA DAY LESSON PLAN AND EXIT SLIP

Tea Day Lesson Overview

- Students bring their own mugs from home; I provide the tea supplies and water.
- We begin class by making our tea
- As we enjoy our tea, we read aloud from Czerski's book and discuss the following topics:
  - Pattern 1 – Convection
  - Pattern 2 – mixing of hot and cold liquids
  - Pattern 3 – sloshing of liquid in a cup
- Students then filled out an exit slip
- Assessment questions were given on the next assessment about the patterns we discussed

Tea Day Exit Slip

1. What is the most important take away from Tea Day?
2. What content can you take from this activity and connect to the real world?
3. Who/what might actually use this in their day to day life?
4. On the scale below rate the lesson.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful was this activity to your engagement in class? Rate and explain.

Low High

1 2 3 4 5

Tea Day Exit Slip

1. What is the most important take away from Tea Day?
2. What content can you take from this activity and connect to the real world?
3. Who/what might actually use this in their day to day life?
4. On the scale below rate the lesson.

Mostly Theoretical	Somewhat Theoretical	Both	Somewhat Practical	Mostly Practical

5. How helpful was this activity to your engagement in class? Rate and explain.

Low High

1 2 3 4 5

APPENDIX L

SCIENCE JOURNAL RUBRIC

Science Journal Template and Rubric

Title - Week # (goes in the title spot for this page)

Date: ____________________

Location: _________________

Time: ____________________

Content

- Reflect on the content of the week.
    - What are we learning about?

Observations

- Where is the physics?
- What did you observe?
- Can you make connections of classroom content to your daily life?

Images/Drawings (With Color)

- These can be in a separate "section" or they can be within the other sections. Images should be described.

Reflection

- What questions do you still have from this week/unit?
- Explain what could you have done better this week and what worked well for you this week.
- Other thoughts or reflections…

Self Grading Based on Rubric Below

Rubric – Explain your reasoning.

4	3	2	1	0
All standards met and exceeded	All standards met	1-2 standards not met	3+ standards not met	Incomplete

Standards for your science journal include having all of the above listed content. Not all sections need to be in paragraph form, they can include pictures, concept maps, notes, drawings, etc. See explanation of standard grading below.

APPENDIX M

POST TREATMENT SURVEY

Post Treatment Survey

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

1. Please answer the question below, using the given scale.

   I am enjoying physics.

   Strongly disagree   Disagree   It's Okay.   Agree   Strongly Agree

2. Rank the following activities from **most engaging to least engaging**.
   a. Physics Crash Course Week
   b. Freefall Lab Inquiry
   c. Physics of the Olympics
   d. Tea Day
   e. Science Journals
   f. Wisconsin Glaciation Seminar & Field Trip

3. Of the following activities we have completed in class, which best helped you **make connections** about physics to your daily life? Rank in order from most to least.
   a. Physics Crash Course Week
   b. Freefall Lab Inquiry
   c. Physics of the Olympics
   d. Tea Day
   e. Science Journals
   f. Wisconsin Glaciation Seminar & Field Trip

4. For the following questions, five (5) is considered high and one (1) is considered low.

   Rate your engagement in class so far.
   1   2   3   4   5
   Rate your confidence level when it comes to making connections to physics in the real world.
   1   2   3   4   5
   Rate your engagement when working with small groups or a partner.
   1   2   3   4   5

5. Which of the following thing(s) have been the most helpful for your learning in class?
   a. labs/activities
   b. Science Journal Reflections
   c. Lecture
   d. Practice Problems
   e. Working with others

6. How often do you make connections of physics content to your daily life (outside the classroom)?
    a. 0 times a week
    b. 1-2 times a week
    c. 3-4 times a week
    d. 5 or more times a week

7. Describe the most interesting content you have learned so far in class.

8. What in class supports have been the most helpful to your learning? Explain.

For example: lecture, videos, pictures, activities, homework, group work, etc