THAYER 2020(T21): COMBINING PHYSICS EDUCATION RESEARCH (PER) AND THAYER METHOD EFFECTS FOR ADVANCED AND COMMON CORE PHYSICS

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Abstract

Peer instruction, Interactive lecture demonstrations, and Physics tutorials are all Physics Education Research techniques and practices used to enhance conceptual understanding of Physics concepts. These techniques allow for active engagement between the students and the instructor and often create an environment that efficiently makes use of the resources inherent in a classroom to develop student understanding. For this project we examined how Physics Education Research techniques and the Thayer Method affected students understanding of physics concepts for both STEM and Non-STEAM majors in two separate courses. The two courses compared were a 1st semester introductory physics course comprised of both STEM and Non-STEM majors and an advanced 2nd semester physics course primarily comprised of STEM majors. Students were given before and after concept inventories for a single topic in physics. Instructor’s used multiple physics education research techniques focused on active learning. While the advanced section enjoyed peer instruction more and believed it was more beneficial to their learning, the introductory physics section experience a larger increase in conceptual understanding.

Introduction

The United States Military Academy (USMA) uses a teaching methodology called the Thayer Method. This methodology is one in which students are responsible for their own learning. They study material prior to attending class and classroom time is spent reinforcing/clarifying lesson material [1]. This paper examined the effects of combing the Thayer Method with Physics Education Research (PER) techniques that emphasize peer instruction and interactive engagements. Large studies have shown that PER techniques applied in introductory physics courses increase conceptual understanding when compared to traditional lecture techniques [2]. In this project we examined the effect of combing the Thayer method and PER techniques. This combination will persist in the Department of Physics and Nuclear Engineering (PANE) at USMA in the 21st century until superseded by a better program, and will be referred to as T21. Instead of comparing the results to traditional lecture techniques, this study compared the impact of T21 on different student populations.

Method

The two groups that were involved in the project were an entry level physics course, Physics I (PH205), comprised of 32 students, and an Advanced Physics II (PH256) course comprised of 34 students. The
PH205 group was composed of a variety of students who were taking their mandatory course. The PH256 course is not required for every graduate but is one of three science options (Physics II, Chemistry II, Biology) that cadets must complete. The PH256 group consisted of cadets who elected to take the course and were primarily Science, Technology, Engineering, and Math (STEM) majors. These cadets are screened and selected amongst approximately 300 other Physics II students based on their grade point average and previous grades in math and science.

The implementation of T21 for the Physics I courses used PER occurred during the mechanics block of courses which consisted of 26 lessons of material. It is the very first topic covered and is foundational to all other physics topics in the core physics sequence. For the Physics II course, T21 techniques were used for approximately 30 lessons of material covering a variety of topics, including circuits, waves, and fluids. This course is a prerequisite for most STEM core courses at the United States Military Academy (USMA), and the material covered is essential to the cadet’s progression in their major.

The application of T21 required that the researchers use a variety of PER techniques and combine them with the Thayer Method. The first PER technique was Think Pair Share. This teaching technique involves presenting the students with a conceptual prompt or question and four to five possible answers. The students then answer the question anonymous to each other but viewable by the instructor. The students then pair up with the person next to them and attempt to “convince” their partner why their answer is correct. The class is given a chance to change their answer and the pairs are then asked to share their reasoning for a particular selection.

Another teaching technique used was peer instruction through student response systems (Kahoot.) To facilitate peer instruction in the classroom the instructor creates short conceptual quizzes which were given to the entire class. After each question is answered, the results are shown on the screen in front of the students. If 75% or more of the class answered the quiz question correctly, then minimal instruction is given. If less than 75% answered correctly the instructor prompts students to discuss why they chose a particular answer. In the discussion each student is allowed the opportunity to debate with each other and discuss why or how their answer was correct. Discussions are concluded with instructors clarifying the physics concepts and ensuring that misconceptions are identified and corrected.

The last technique used was Interactive Lecture Demonstrations. This technique involves using a physical application to demonstrate a concept in class [3], [4]. Students work in small groups and predict results of the demonstration, and compare predictions. Each group then applies the physics equation they believe best modeled the demonstration to confirm their predictions. Finally the class conducts the demonstration and observes the results.

Measures

To measure the effects of T21 all students were given a before and after physics concepts inventories. The inventories were given prior to beginning the multi lesson block of instruction and the lesson immediately after the block was complete. The block of instruction occurred over a time period of approximately two months. The inventories were taken without any assistance and the students were informed that results of the inventory had no effect on their course grade. The students were also given a questionnaire which asked which PER technique they preferred and which technique was most beneficial to their physics understanding.

Results

The Physics I students took a concepts inventory during the motions and forces block of instruction on a voluntary basis. Students were assigned points for completion of the inventory regardless of their response the results are shown in Figure 1.
Figure 1 shows a 12% increase in the understanding of concepts during the trial, and what is significant about this statistic is the correlation made between this increase and the increase in conceptual knowledge with Physics II.

During the 30 lesson trial period for T21, the students in Physics II were tested on their knowledge of basic physics concepts similar to the Physics I course. Students were assigned points for completion of the inventory regardless of their response. The concept inventory occurred during the waves block of instruction before the test occurred on the lesson material. The results of this inventory are shown in Figure 2.

As shown in Figure 2, there is an 8% increase in understanding of concepts after the students experienced T21 teaching methods. Although the students in Physics II started out with a higher percentage of correct responses. A possible reason they scored higher is that the students in the Physics II section are in general high performers in the STEM field, and as stated previously they are hand-selected.

After further comparison of the results, we see an increase in conceptual understanding by both groups. Figure 3 shows that the amount of gain was similar in both groups. Of note, the PH205 group’s final conceptual understanding percentage was still below the PH256 initial conceptual understanding.
Regardless, both courses benefited from the T21 implementation to some degree and the results of a 12% vs an 8% increase in understanding is enough to consider more use and study.

After T21 was implemented and tested, the students were also asked to give their opinion on which teaching style they prefer to be taught. In this survey the students were asked two questions: 1. what method of teaching do you like the most? And 2. Which teaching method contributed most to your understanding of physics? The results from the first question are shown in Figure 4.

In Figure 4 T21 tested favorably with both Physics I and II students as approximately 80% of students in both sections decided that they like T21 more than traditional lecture. Another interesting comparison is that 15% of those in Physics I still like to learn through traditional lecture, but those in Physics II did not or were indifferent. The reason for this is unknown and warrants further study. However, since the purpose of this study was to determine effectiveness in learning, the second question asked of them was considered more important. The results to the second question are shown in Figure 5.

The advanced section (PHYSICS II) favored T21 more than traditional lecture, and the PHYSICS I students favored T21 as well, but about one third would prefer a lecture style method of teaching. However, the results in Figure 5 are very encouraging for T21 as the students responded favorable to peer instruction and activity based discussion on the topics rather than the traditional lecture style. This combined with the results of Figure 1 shows enough benefit from T21 to be strongly considered for the permanent teaching style of the future.

Conclusion
This study investigated the combination of PERs and the Thayer method of teaching into Thayer 2020 (T21). The comprehensive study on conceptual understanding of physics concepts in an active learning environment indicates that T21 is effective at improving understanding of physics concepts and the student response to T21 is highly favorable. This comparison between Physics I and II indicates that both parties showed a similar increase in understanding through T21. More studies could include a larger student population and an in depth lesson by lesson study in overall concept understanding.

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References


