



Real life Project based Physics Teaching related to Majors (“RPPTM”) Teaching Model for Health Science Undergraduates

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ABSTRACT

In this article, we describe a teaching model that was developed for an introductory-level physics course for allied health students. The aim of this model is to encourage and to engage them in the creative process of learning by posing collective challenges related to real world problems. The culmination of the course involves designing a project working with data analysis software and laboratory techniques related to real world applications. Throughout the course, students experience inquiry-based learning, open ended questions, and independent research. The model encourages students to work beyond the physics classroom to engage in questions and research related to their majors. We describe the motivation for the model and the implementation and outcomes of the model, report on impact on students, and suggest ways in which creativity can be encouraged in all science courses.

Keywords: Teaching and learning, model, Physics, undergraduate, health science, project, laboratory, lectures, real world applications.

INTRODUCTION

Teaching Physics to allied health majors is a challenging task. Traditional lecture and laboratory investigations within a one or two semester physics course typically do not connect directly with the student’s majors or areas of interest. To engage allied health students in our traditional general physics course, we introduced a new teaching model “**RPPTM**” (**R**eal life **P**roject based **P**hysics **T**eaching related to **M**ajors) to teach physical concepts in a fun-filled way of learning directly related to the student’s major programs. Within this model, we include an inquiry based research based project as part of the laboratory course, engaging students to observe actual physical actions/reactions and then apply physics principles to support their observations. This is in keeping with the American Association of Physics Teachers statement that one of the important goals of the introductory physics laboratories should be designing experimental investigations and evaluating data (AAPT, 1998). Efforts to attain this goal include the Scientific Community Labs (SCL) at the University of Maryland (Redish, 2015) and the Investigative Science Learning Environment (ISLE) labs used in small to medium enrolled physics courses (Etkina et. al., 2006).

In our college, the majority of students taking physics are allied health majors. Most of these students will work as athletic trainers, exercise physiologists, strength and conditioning coaches, and physical therapists. Many of the allied health fields have moved, or will move, toward entry level master's or doctorate degrees for entry into the field. As such, much of the undergraduate training within the student's major field is focused on competency and/or evidence based practice (Johnson et.al, 2010; Welch et.al, 2013). Thus, it is critical for students in these majors to understand the principles of physics which underlie the field of biomechanics, how to read research literature in the field, and to critically review the research methodology used.

To help ensure that students are leaving our college with the above skills, we revised our undergraduate non-majors physics course using the **"RPPTM" model**. Students in our class are actively immersed in solving problems related to real word situations, reviewing current literature in the field and developing research projects themselves as part of the laboratory component of the course.

Lectures

For example, the study of impulse and momentum is incorporated into the lecture by first watching a short video clip: Measuring Force Impacts in Helmets (<http://insidescience.org/content/measuring-forces-impacts-youth-football-helmets/769>).

Students are then asked about their experiences related to concussion injuries (many have had concussions) and about their knowledge of the long term effects of concussion injuries in football players that has been in the news extensively over the last few years. Then students are placed into small groups and are provided with a problem such as:

Assuming a head mass of 3.2 kg and that a hit by an opposing player causes an average acceleration of 19g, what is the average force acting on the head? What impulse is imparted to the head if we assume that the collision lasts 7.78 ms.

The quantitative solution to the problem is not particularly difficult for most student groups. What is difficult for students is how to discern the methodology researchers use to gather this type of data and how it can be used to make decisions related to helmet use and choice. To help students more effectively understand how this type of data are gathered, they are asked to review a recently developed methodology for rating football helmets known as the summation of tests for the analysis of risk (STAR) (Rowson et. al, 2011; Virginia Tech Helmet Ratings, 2015). For many students, reading an article that puts theory to practice was an eye opening experience. While many textbooks have problems such as the example given above, there is still a disconnection for students. Seeing research on helmets that are actually in use (and that some of the students have used) has opened the door to rich discussions centering on everything from the validity of the tests used for the rating, how to scale the rating based on non-collegiate levels of play, how the curves are developed, and the differences in youth versus collegiate football players. Since the students in the course have training in applied physiology and anatomy, they typically speak to the issues that surround concussions in younger athletes whose physiology may respond differently than an adult player.

Laboratory

While useful in a lecture setting, a research study such as developed for the rating of the football helmets is beyond the scope of a one semester course. The question remains as to how students practice the process of inquiry, relate theory and practice, and develop meaningful projects. First, it is necessary for students to learn how to use the data logging equipment and software. Our college has invested in the Vernier data logging systems and we use their sensors for our laboratory experience. During this time, as a means of informing their own research projects that will be conducted later in the semester, students are provided with current research articles which utilize equipment that is available to our students (i.e. force plates, accelerometers, video analysis, etc.). As part of their weekly laboratory experiments, students are asked to read these research articles and discern several important aspects from the literature that they will need to consider in their own project development. These include identifying the independent, dependent, and controlling variables in the paper reviewed, stating the research question that is being asked in the paper and determining how the researchers ensured that their data was both accurate and precise. We typically incorporate at least two weeks of discussion into our pre- laboratory lectures to discuss their findings.

With the advent of electronic data logging devices, students are sometimes very unaware of the precision of their measuring devices or how to account for them when taking data measurements. As such, this process becomes an important component of discussions about research articles the students are reading. For example, students read a recent article by Koizumi et Al, (2014) that looked at the impact forces on modern soccer balls using force plates. They noted that their force plate had a natural frequency associated with it. To minimize this effect, 12 trials were performed and the average peak value used. For the majority of students, the idea that researchers would need to consider this as a factor and the number of trials to normalize this effect is eye opening. After discussing the article, students are much more aware of the need to consider the precision of the measuring equipment and indeed ask instructors for this information.

Student Projects

Development of student projects typically begins mid-semester with at least one required submission prior to the project start. The projects required students to utilize real time data loggers, computer based software and digital video analysis for compiling and analyzing data. The first required submission is a project proposal. This proposal is similar to a research proposal that might be required in a graduate program of study. The proposal involves a review of the literature with at least three references from the primary literature, research question, identification of relevant variables, and well developed methodology. Students are required to redo their proposal if the above requirements are not sufficiently addressed. An end of semester, presentation provided an opportunity for other class members to engage in discussion regarding experimental design, results and ideas for continued research.

Some examples of student projects are provided in table 1. The range of projects in table 1 indicate that students were creative in their approach to projects and applied the concepts in classed to research real world problems. Projects reflected a wide range of topics and interest. Students typically find it challenging to develop research questions but find the project to fun filled learning activity which that can relate to their major coursework (Koizumi et.al, 2014; Munakata et. Al, 2015).

Table 1- Sample of Student Projects Undertaken

Project Title
Measuring the effectiveness of a lacrosse helmet.
How does the weight of shoes effect the height of a jump?
Building sustainability by using exercise equipment to generate electricity.
Forces produced by composite versus aluminum-composite softball bats.
The effect of an Individual's height and posture on the Projectile Motion of a Soccer Ball.
Forces exerted by athletic shoes during plyometric jumping exercises.
The effect of shoe type on frictional forces.
Field hockey hits and their effect on ball speed.

RESULTS AND DISCUSSION ON RPPTM MODEL

We started using the RPPTM Model in 2011. A representative list of projects undertaken by students is given in table 1. Since 2011, we have seen an overall rise in student grades for the first semester of the course where this model has been used as seen in Figure 1. The same types of questions have been used on final examination over the course of the study. Perhaps more importantly, students that have completed the course are continuing to utilize physics principles, data logging techniques, and data analysis techniques in their upper level courses in the allied health majors at the college. Physics instructors are frequently asked by students if they may borrow our equipment for their projects. Students also ask for advice on how to set up research projects and also have been invited to listen to allied health student research proposals and project presentations that are required as part of the College's commitment to capstone experiences in each major. Capstone projects last year included allied health students using EMG data to perform a kinetic analysis and an analysis of jumping techniques using force plates.

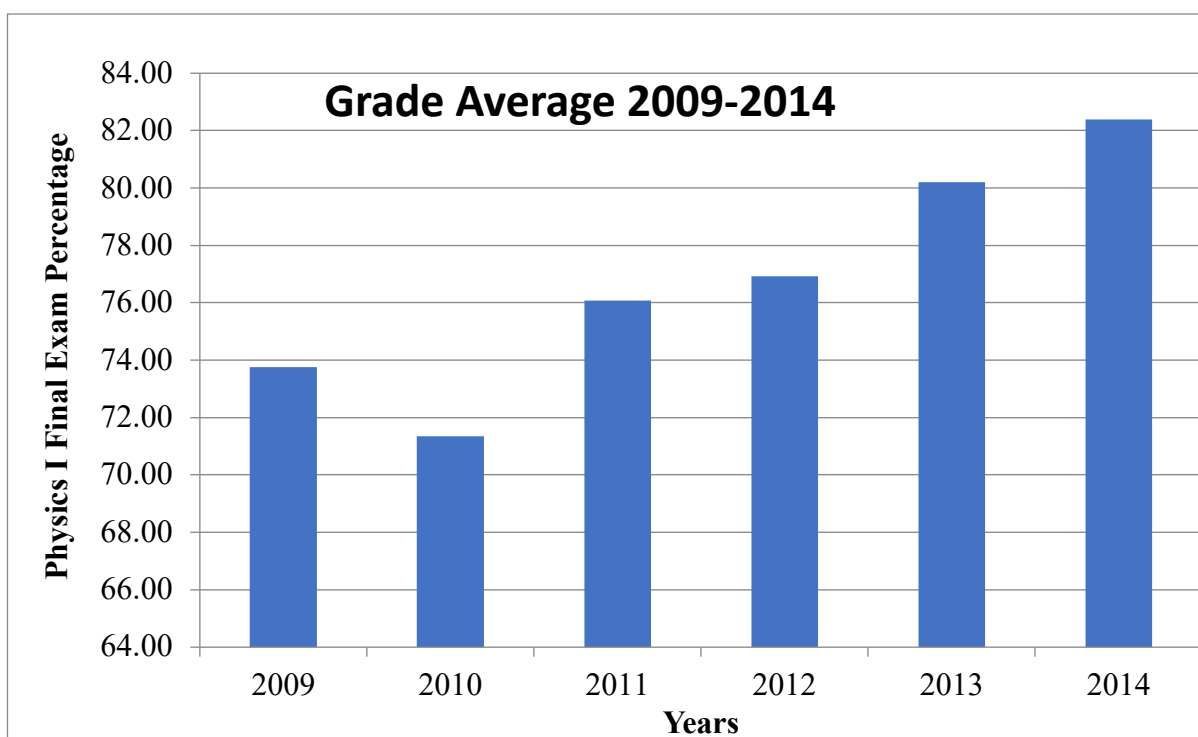


Figure 1: Grade average from 2009 to 2014

In the fall 2015, a more detailed assessment was initiated in regards to the use of the proposed model. Figure 2 (n =40) below shows how students' grade improved from pretest to posttest where a posttest was given after introducing the laboratory project and pretest was given near the beginning of the course and before laboratory project. Additionally, lecture materials included additional relevant and relevant problem solving sessions as noted above were presented after the initial pretest. An increase in students' grades can be seen in posttest from pretest.

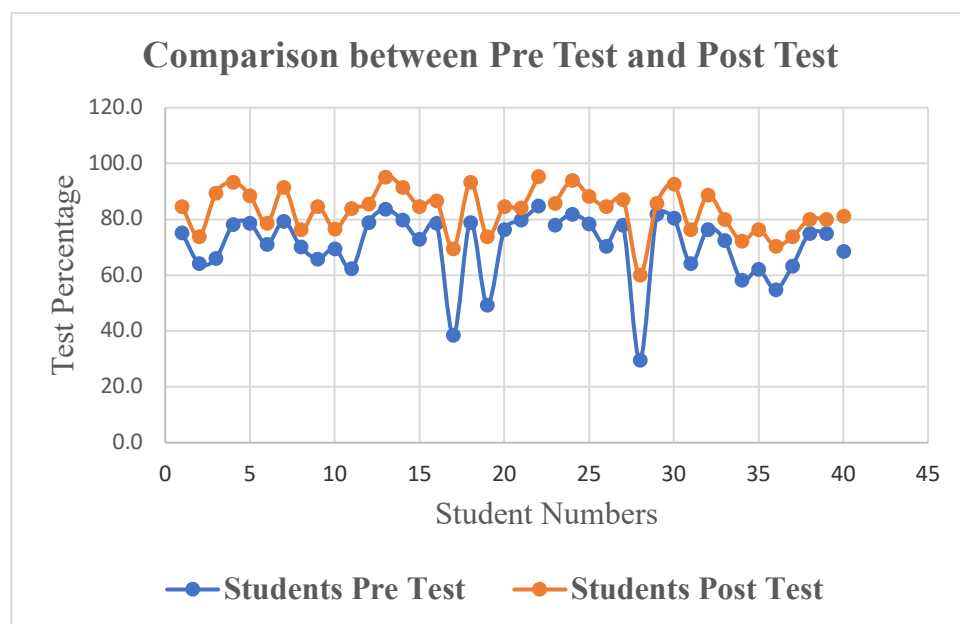


Figure 2: Comparative grades in pretest and posttest for Physics I in fall 2015

From figure 2, it can be seen there were four students (student # 17, 19, 28 and 31 from the graph) who received either below or at the level of passing level grade (60%), and their grades in pretest were 38.5%, 49.4%, 29.6%, and 64.1% respectively, but after working on the project and continued enrollment in the course, when the posttest was performed, their grades improved and they obtained 69.5%, 73.9%, 60.2%, 76.4% respectively. Hence, the students improved in their depth and breadth of knowledge.

Figure 3 (n=40) below shows the grade distribution in two different sections of Physics I course including three exams. Three exams were given during the Physics course as Exam 1, Exam 2 and Final Exam. It can be seen that students attained higher grades over the course of the semester. An increase in the final exam grades in comparison to exams 1 and 2 can be clearly seen.

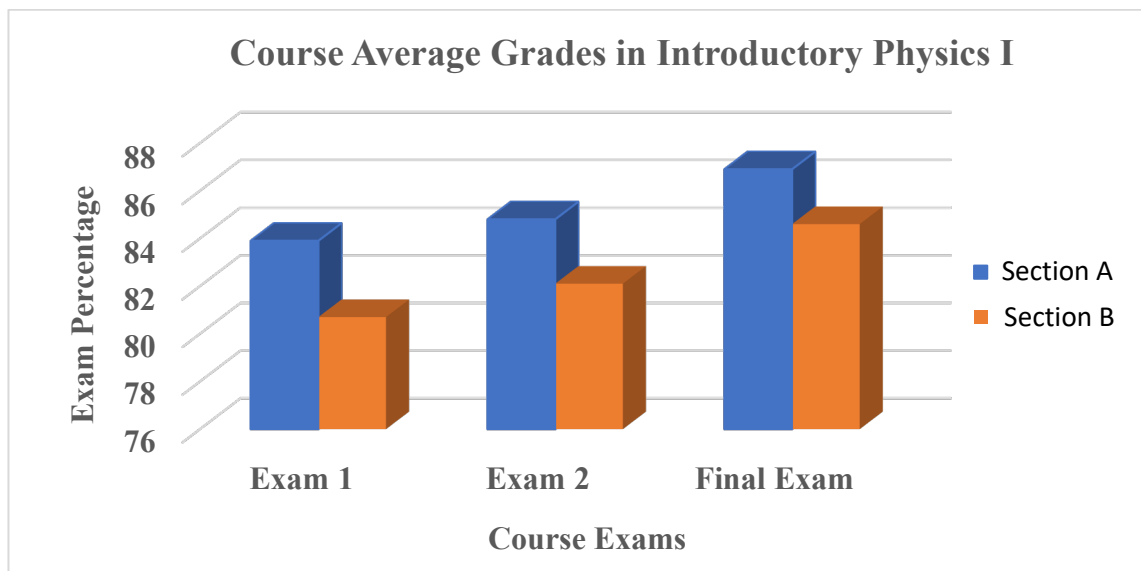


Figure 3: Grades distribution among two sections of Physics I course in fall 2015

Figure 4 shows the percent gain of the 40 students evaluated in fall 2015. The percent gain between the final exam and midterm grades was determined as follows:

Percent gain = Percent grades in Final exam – Percent grades in Midterm exam

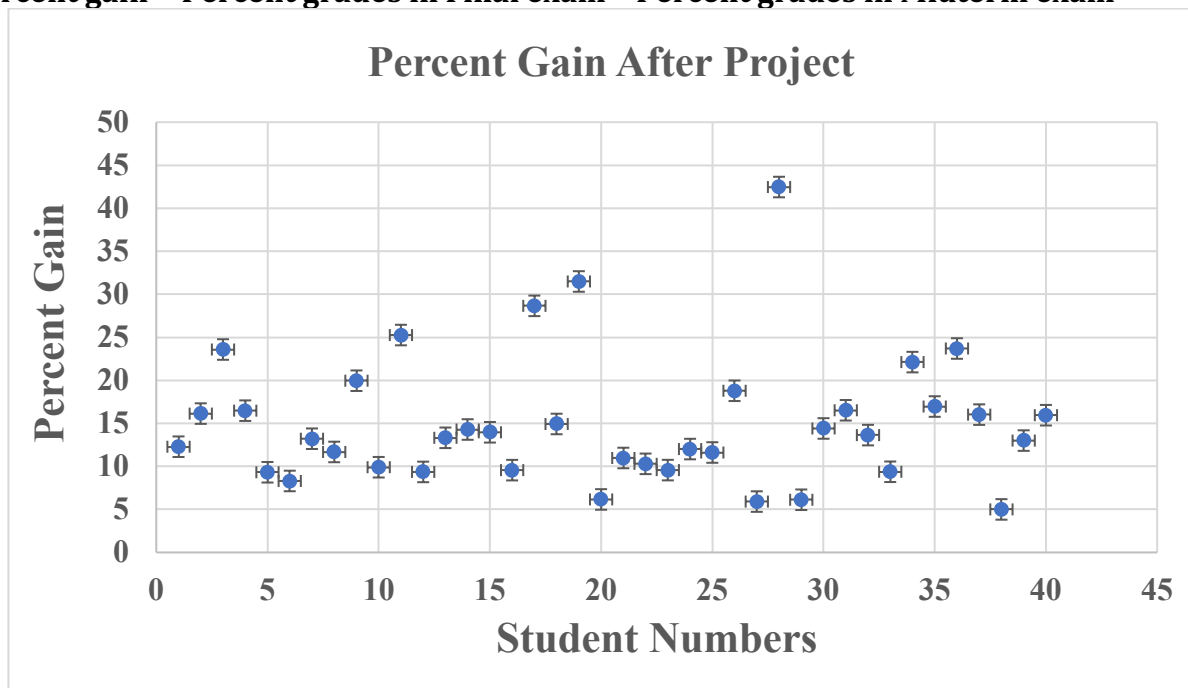


Figure 4: Percent gain in the Finals after project submission for Physics I students in fall 2015 shown for total 40 students taken this course.

From the figure 4, it can be seen that the percent gain for 40 students within both sections of Physics course varied from **0% to 40%**. Students who had a weaker physics background and received the lowest grades on the pretest (student # 17, 19, 28 and 31) achieved the highest gains.

The RPPTM model aids students with a wide range of skill sets that are found in a non-majors physics course. This model aids students with weak backgrounds in attaining skills and provides and provides students with strong backgrounds the opportunity to relate physical concepts to real world applications and with their own major courses (Terry et al, 2016).

For the bottom 25% of the course (10 students) who were either at or below a passing grade for the course, a curve for their grade at three different points: 1) before project, 2) at the time of project, and 3) after the project was plotted and can be seen below in figure 5.

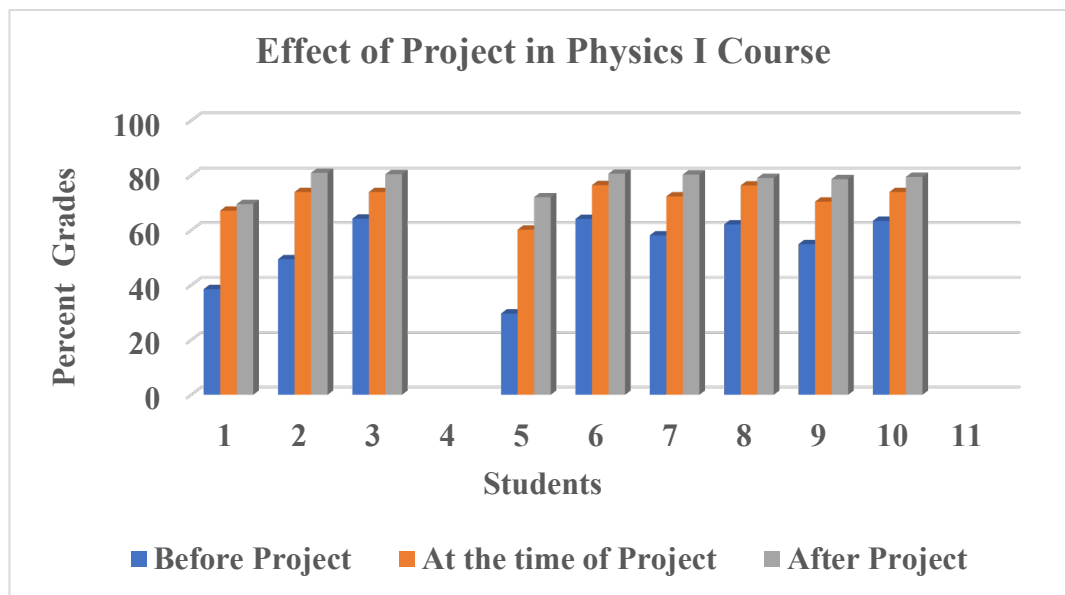


Figure 5: Grades improvement for the students with weak learning skills using RPPTM model for Physics I recorded in fall 2015.

It can be seen clearly that the blue bar shows a low grade for all of the students with some below a passing (60%) grade. During and after the project, all students showed significant increases in exam scores.

During the laboratory sessions, after introducing the project and deciding the research question, students were given 2-3 weeks (where they spend approximately 6-12 hours roughly) to work on their project outside the class room in their own environment i.e. campus, room, family, friends, dorm etc. Students were asked to estimate the time they spend on the project outside of the lecture and laboratory setting. Figure 6 shows the relationship between times spent on the project, project grades, and gain in final grades because of project grades. The gain in final grades based on project grades are calculated as shown below. The project is 20% of the labs grades and labs are 20% of the course total, so the gain in final grades based on project grades are:

$$\text{Percent Gain due to project grades} = [(20/100) * 20 * \text{Grades in project}] / 100$$

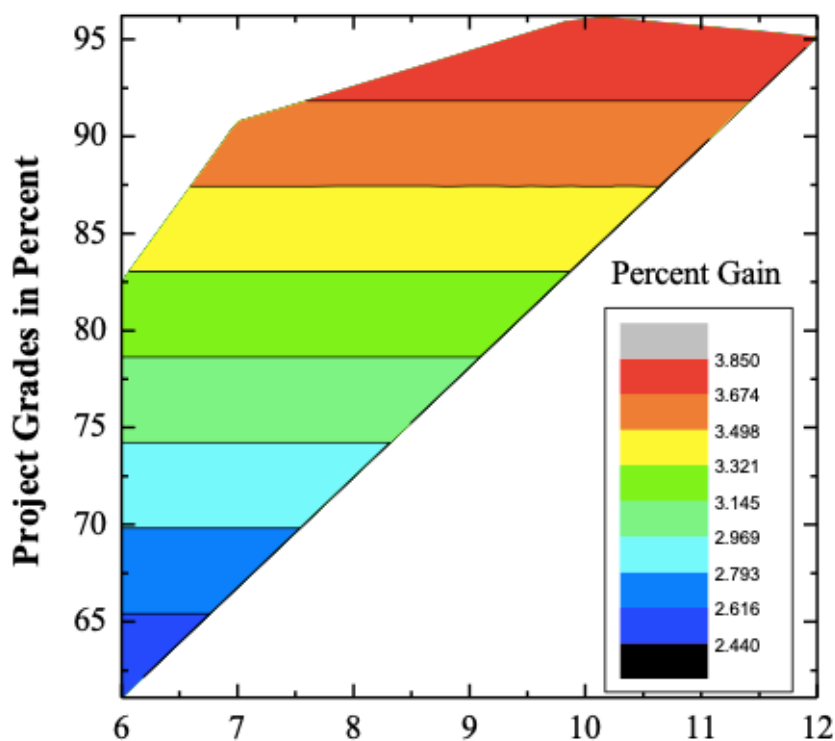


Figure 6: A relation between hours spent in the project, grades of the project and gain in the final of the course in Physics I for the fall 2015.

The maximum percent gain in the finals due to project is 4% as shown in the insert of figure 6.

CONCLUSION

RPPTM model was found significant in introductory and general Physics courses taught to health science majors and Physics minor undergraduate since 2011 and have been showing significant good results in students learning and understanding now as well. According to the data provided above for the just passed fall semester of Physics courses, it can be seen the RPPTM model helped students to understand the concept of Physics in a fun way without giving them hard time and it allowed students to work outside the classroom with their won love ones and come up with significant results, discussion and conclusions those help them understanding and relating Physical concepts with their own major programs and real world applications.

Open-ended questions were used to assess the evaluative effects of the course and the extent to which students found the course an engaging and productive experience. Comments from students indicated that the opportunity to work on research projects with real world applications helped them to see the importance of physics in their majors (i.e., *It was hands on and it made us think and apply what we learned to our majors, it was interesting to see that the formulas and graphs that could be applied to real life biomechanics*). Further, the active, connected learning aspect of the course (that allowed students to link course content to issues related to their majors) was appealing to students (i.e., *it gives a real world experience to the physics course, I learned more about physics and felt the hands on learning improved understanding*).

At the end of the fall 2015 semester, after submission of projects, a survey was given to the students and their feedback and results are shown figure 7. There were five questions asked in the survey on RPPTM model. The questions asked the students to reflect on how the course model helped them to understand the physical concepts presented in the class and how they were able to connect the course to their majors. A Likert scale was used with a “1” signifying strongly disagree, “2” disagree, “3” neutral, “4” agree, and “5” representing strongly agree, and percent of students who reflect these numbers were counted. These results are plotted in the figure 7.

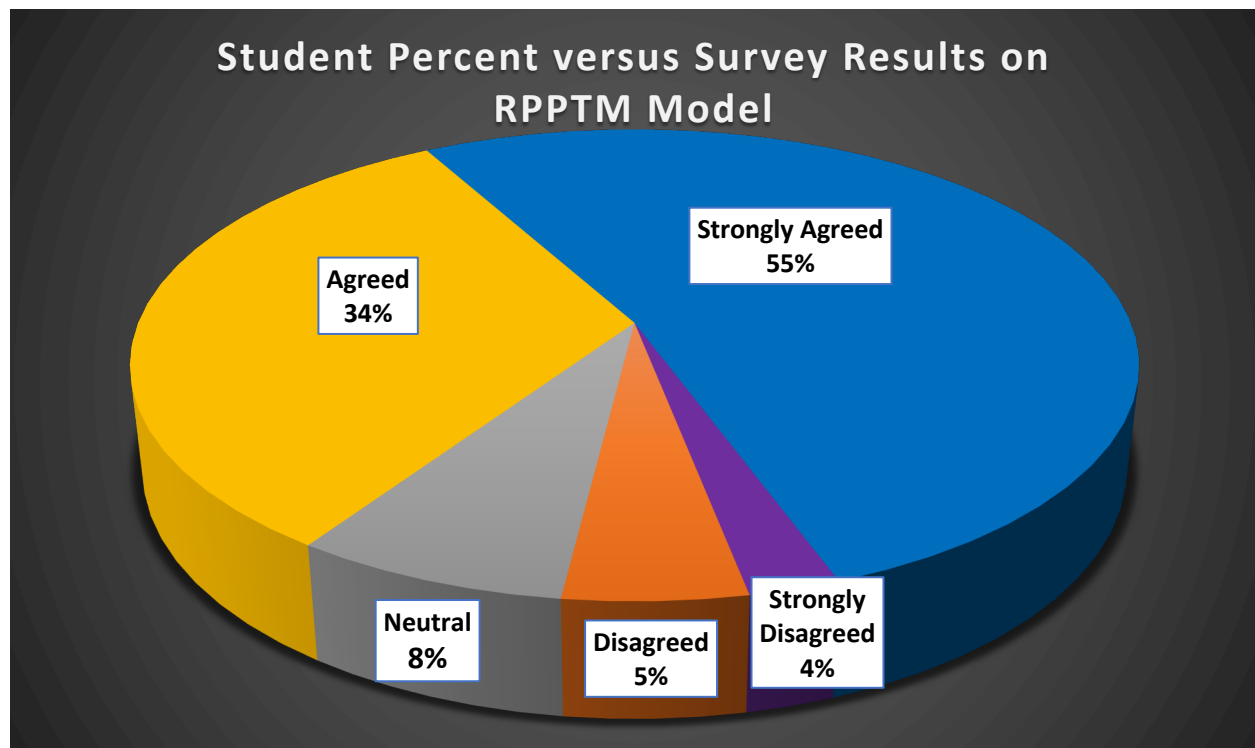


Figure 7: A Pie chart showing percentage of students (n = 40) participated in the RPPTM Model survey given in fall 2015 for Physics courses.

According to your given example of pie diagram as you showed in the previous version (attached), I am showing the same thing as percent responses of each question where 3% (1/40) are strongly disagreed, 5% (2/40) are disagreed, 9% (3/40) are neutral, 34% (13/40) are agreed and 55% (21/40) strongly agreed.

Finally, an overall grade graph is shown including grades from 2009 to 2015 with error bars, in figure 8. It can be seen that students' grades in the Physics courses have been gradually increasing since 2011. Fluctuations in grades can be seen in years 2009-2011 before the RPPTM model was implemented. These results indicate the RPPTM model provides a significant way of improving teaching and learning in the physics classrooms for health science majors and it may also be useful for other science courses.

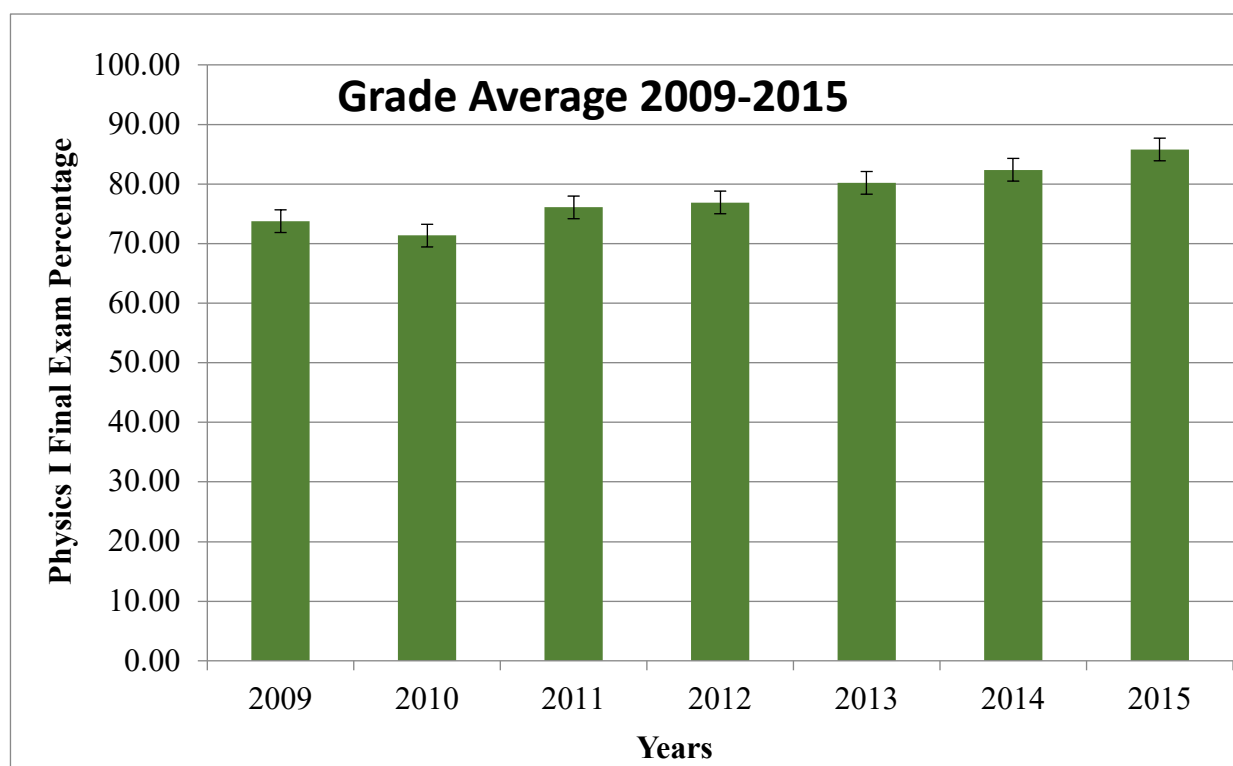


Figure 8: Overall grade distribution of final exam since 2009 to 2015 for Physics courses for Health science majors with error bars.

Further development of the RPPTM model continues through the addition of new activities into the course such as those described in this paper.

The use of relatively inexpensive data-logging equipment in undergraduate laboratories allows students to develop sophisticated research projects. Through the introduction of real world scenarios in the lecture and analysis of current literature, students are able to synthesize research questions. Additionally, the work done using the inquiry based model provides a basis for further research work in a student's major.

In summary, it has been observed that the RPPTM model aids health science undergraduates in increasing students' interest in learning and applying physical concepts to real world applications. Additionally, students continue to utilize the skills obtained in their physics course as part of their upper level undergraduate coursework within their major.

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