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Improving Physics education among Engineering Technology students

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Abstract:

General Physics is a required course of Engineering Technology and Computer Technology program at Queensborough Community College. But often many students struggle to complete required physics courses successfully. During this study, we will present the change of their attitudes toward physics concepts after exposing various real life examples. Student groups of five each were given a Physics topic for exploration. Their task was to find many practical applications that apply the topic. At the end of the semester they presented their findings with basic theory of the topic to entire class. Other students were given a chance to evaluate their peers. In addition the project students were assessed regularly by quizzes, exams as well as student assessment of learning gains (SALG) and science learning attitude (CLASS) surveys. At the end of the semester cumulative final examination was given to assess all topics in the course. Comparisons of the student performance on their research project topic to other topics were done to effectiveness of this method.

Introduction:

The Physics department of Queensborough Community college offers a variety of introductory level physics courses. Among them PH 201, General Physics, is a required course for Engineering Technology and computer technology majors. However, approximately 50% of students failed to meet minimum requirements to pass the course. Even after passing the physics course, students are still deficient in the understanding of some physics basic concepts. Some of these students were able to solve problems routinely using given or memorized equations, their acquired conceptual knowledge seems to be at a minimal level. Recent work by several educators suggests that the traditional lectures do not provide the solid foundation or conceptual knowledge required for a better understanding and the application of physics principles in solving complex problems[1]. To increase their interest and motivation we can show them the connection between physics principles they are learning and application in real life. This teaching strategy can be used to turn students into active learners rather than passive recipients of information. If students are given the opportunity to explore on their own and provided an optimum learning environment, then the material would become more interesting to them. During this study we compared the basic knowledge of physics concepts and simple problem solving skills in two different student groups. One group was given traditional lectures and the other group was given assignments to explore applications of physics principles. Since Queensborough community college offers PH 201in several sections, using two different sections of a course would be feasible for a comparative study. Collaborative group study not a new method. This method had been previously tested in other institutions such as elementary & secondary schools, community colleges, and senior colleges[2-7]. But most of these studies are only based on a single topic or area. These studies have yielded positive results on group based teaching. This success has been attributed mostly to the increased peer interaction and active participation during the lessons. On the other hand, there is considerable evidence collected by researchers in physics teaching and learning that traditional instructional methods - largely lecture and problem solving - are not effective in promoting conceptual learning in physics. There is also widespread evidence that active learning methods enhance the conceptual knowledge of students[8-10]. In this paper we investigate the impact of cooperative work on physics applications on students' conceptual understanding, problem-solving ability and attitudes on physics and physics learning. Students spent time in groups outside of class exploring physics applications they encounter. We used students' class tests, final exams, concept inventories and attitudinal surveys to evaluate the impact.

Methods:

In this study we used two different PH 201 sections of approximately 24 students in each. One section, control group, received instructions using traditional lectures and recitations. Students in the other section divided into 5 groups with 4-5 students in each group. One of the topics in mechanics such as 1-D kinematics, projectile motion, Newton's laws, Momentum, Work-energy , was assigned to each group randomly. Each group was asked to work together and find applications of physics concepts related to daily life and prepare a power point presentation at the end of the semester. Since learning and problem solving ability of Physics depends largely on a working knowledge of mathematics, students from both sections were tested at the beginning for correlation study. Both sections were taught by same instructor and covered the same amount of material. The student's conceptual understanding and problem solving ability was assessed by Quizzes, exams, cumulative final exam and standard Force Concept Inventory(FCI). At the end of the semester the final exam was given to cover all areas. The scores received by students for of each problem is compared with their research topic and with scores in control group. Pre- and post-tests in science learning attitudes were measured using Colorado Learning Attitudes about Science Survey[11] (CLASS).

Results and Discussion:

Initial conceptual knowledge of both groups was similar as indicated by FCI pre test. The control group had on average 5.4% correct responses and experimental group had 5.3% correct responses. Post FCI test given at the end of the semester shows slightly higher conceptual understanding (36 % correct in experimental group compared to 32 % correct in control group) among students in experimental group. The final exam grades were analyzed based on scores in each problem. The results and research topics of each group are summarized in table 1. According to results shown in table 1, not all groups scored highest for their research topic problem. Group 1 conducted their research on 1-D motion and scored highest in 1-D motion problem compared to other 4 problems. But group 2 who researches on 2-D motion also scored high on 1-D motion problem. The 3rd group who conducted their research on Newton's laws couldn't score high on that problem. The group 4 received 50% on their problem as well as 2-D motion problem. The group 5 also couldn't score high on the work energy problem. They did better on the 1-D motion problem. On the other hand, the groups on momentum and energy received highest scores in those two problems compared to other groups. Group 1 scored highest on the problem of their topic but others score more than the group 1. There is some trend towards the conclusion of research topic help students to master problem solving in that topic. But this data in general is inconclusive. We will continue same procedure with other student groups to collect more data. Overall average grades of groups 2, 3, and 4 are greater than the control group. The average of group 5 is slightly less than the control group. But group 1 had very low average overall grade compared to all of the other groups and control group.

Group #	Research topic	Average scores of final exam problems				
		1-D motion	2-D motion	Newton's laws	Momentum	Work & energy
1	1-D motion	30%	10%	10%	20%	5%
2	2-D motion	50%	30%	40%	20%	20%
3	Newton's laws	40%	50%	45%	35%	30%
4	Momentum	45%	50%	35%	50%	30%
5	Work-energy	45%	30%	15%	15%	40%
Control	N/A	40%	30%	32%	30%	25%

Table 1: Average scores of each problem Vs research topics.

Based on the pre and post surveys given to students, experimental group had increase in interest towards science compared to control group. The increase in science interest in control group is only 18% after taking the course. But experimental group has shown 36% increase after the course. The experimental group indicates willingness to take higher level physics courses more than the control group.

Conclusion:

Students in general physics classes were given assignments to work as groups to find real life examples of a specific topic in physics. Preliminary results of overall final exam grades of student groups and their research topic of finding real life examples do not exhibit direct correlation. However, some collaborative groups outperformed the others on final exam problems related to their research topic. But after the research project their interest in science has increased significant amount while control group only had slight increase in science interest. Further detailed study is required to achieve clear conclusion.

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