Assessing Students' Attitudes In A College Physics Course In Mexico

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Abstract. Considering the benefits of modeling instruction in improving conceptual learning while students work more like scientists, an implementation was made in an introductory Physics course in a Mexican University. Recently Brewe, Kramer and O'Brien have observed positive attitudinal shifts using modeling instruction in a course with a reduced number of students. These results are opposite to previous observations with methodologies that promote active learning. Inspired in those results, the Colorado Learning Attitudes about Science Survey (CLASS) was applied as pre and post tests in two Mechanics courses with modeling. In comparison to the different categories of the CLASS, significant positive shifts have been determined in Overall, Sophistication in Problem Solving, and Applied Conceptual Understanding in a sample of 44 students.

INTRODUCTION

Understanding of what is important in a classroom has changed dramatically since formal research in Physics Education began. Today, the emphasis in the study of the hidden curriculum is as relevant as those in conceptual understanding or in problem solving skills. One example of this hidden curriculum is student's beliefs. The importance of students' beliefs and expectations has been increasing in the last years, since these were found to be one of the points to improve in the students. For instance, previous studies have shown that traditional courses only diminish students' motivation [1].

If a group of scientists are considered experts, it is possible to identify similarities in their beliefs and expectations on Physics and its learning. Beliefs and expectations of future experts tend to be closer to those of an expert that is contrary to a normal student.

The differences in beliefs and expectations between future experts and normal students should tell what changes should be made in the learning process to bring both parts closer. It has been also shown that improvements in conceptual learning do not imply an improvement in beliefs and expectations of students.

Nowadays the Colorado Learning Attitudes about Science Survey (CLASS) [1] is one of the available tests to assess students' perceptions about Physics and its learning. This test has also been modified for other subjects as Chemistry [2] and Biology. It has been translated to many languages, thus providing a standard test to be applied to all students without taking into consideration the problems involved in foreign language implementations. This survey consists of 42 items with 8 different categories. One factor that makes this test different from others similar like MPEX [3], is that the categories were created statistically during its validation and not defined *a priori* by the group of experts. Briefly, the categories of the CLASS test are: Personal Interest, Real World Connection, Problem Solving General, Problem Solving Confidence, Problem Solving Sophistication, Sense Making/Effort, Conceptual Understanding, and Applied Conceptual Understanding.

In some studies it has been observed that students do not improve their attitudes in traditional courses nor in active ones [1, 3].

Modeling Instruction [4] is a methodology for teaching Physics based in the modeling theory introduced by Hestenes [5]. The methodology is characterized by the incorporation of systematic discussion on the modeling process and the techniques required in problem solving and also the selection of proper problems to develop on group work sessions.

In a previous study conducted by Brewe, Kramer, and O'Brien [6] it was found that modeling instruction was able to produce positive shifts in the CLASS. Their study considered two college courses, one in mechanics and the other one in Electricity and

Magnetism. The Introductory Mechanics course showed positive shifts in all the categories except Sense Making/Effort and significant positive shifts in Problem Solving General, Problem Solving Sophistication, Conceptual Understanding, and Applied Conceptual Understanding, while the Electricity and Magnetism group had positive shifts in all the categories measured by the test while only a significant shift is showed in Personal Interest.

Recently, it has been reported the results from the first implementation of modeling instruction in some courses at Tecnológico de Monterrey, which showed gains in learning that doubled those found in traditional courses [7]. The Force Concept Inventory [8] was used to assess the concept learning in Mechanics in that study. Given these good results in learning, it is interesting to know what does happen with the attitudes of those students, establishing the question of this study.

In this article the results obtained in the second implementation of modeling instruction in a Mexican institution are presented. Given the characteristics of the sample is necessary the use of non-parametric statistics to determine the significance of the positive shifts observed.

THE COURSE

The course was taught with the methodology based on modeling theory [4]. The students worked in collaborative groups, in which they developed models of physical situations on whiteboards. Later, they could share their models with the rest of the class, and then established a discussion about the different proposals. The working groups were formed randomly. Each group was made up of four or five students and was changed three times in the semester. The professor made sure the students had the necessary tools to build the models through activities previously made outside the classroom. This was the second time that the professor taught with this methodology, for what he is considered an early-adopter teacher. The course was held without the support of a textbook and the lecture time given by the professor never took more than 10 minutes in a 50-minute class.

DATA COLLECTION AND ANALYSIS

For this study, two 38-student groups with modeling instruction were considered, both with the same professor. The pre test was taken in the first week of the semester and the post test was taken a week before the end of course.

Since not all the students took both pre and post tests, it was necessary to remove them from the sample. The influenza A virus (H1N1) lead to the end of the semester a week earlier and therefore lost some data, but 44 students is a good number to work with for this study.

The CLASS test used in this study was a Spanish version that has been used in the last few years at Tecnológico de Monterrey. Bilingual speakers validated the test's translation to Spanish.

For the initial processing of the information, the CLASS template [9] was used. The pre and post test percentages of like hood to experts was calculated on that template. In a preliminary analysis of the data, it was observed not to have the normality property, which is needed in order to use parametric methods in statistics. Therefore the Mann-Whitney test was used to find the statistical significance in the differences of the pre and post results for all the categories (shifts). The computed shifts were obtained by subtracting the individual pre and post results and then by computing the average value. The idea behind this is to be able to use the program SPSS to find the significance of our findings, since the difference in pre-post is very small; there was no way to ensure the findings were significant without statistical procedure.

TABLE 1. CLASS test results. * p < 0.1, ** p < 0.05

Class category	Pre	Post	Favorable shift	Unfavorable shift	Favorable significance	Unfavorable significance
Overall**	68.35	71.40	3.05	-1.87	.056	.186
All*	70.60	74.39	3.78	-1.36	.097	.290
Personal Interest	75.39	75.30	.08	-1.06	.730	.954
Real World connection	77.30	82.20	4.92	-1.70	.206	.776
Problem solving general	74.27	77.19	2.92	-2.03	.359	.577
Problem solving confidence	81.25	83.52	2.27	-1.70	.683	.825
Problem solving sophistication*	59.62	65.91	6.29	0	.085	.838
Sense making	75.65	76.95	1.30	-.16	.900	1.000
Conceptual understanding	70.00	74.55	4.45	-1.74	.406	.395
Applied conceptual understanding**	59.20	67.97	8.77	-3.90	.009	.108

RESULTS AND DISCUSSION

First of all, the results obtained in the pre test were between 59.20 and 81.25 percent of responses as experts, while in the post test were from 65.91 to 83.52 average response as an expert. Hence, the minimum value has increased, while the difference between the maximum and minimum values has decreased. The highest shifts found were in Applied Conceptual Understanding, being of 8.77, and in Problem Solving Sophistication with 6.29.

All the favorable shifts found in CLASS were positive with exception of Personal Interest, which had a negligible negative shift. The favorable shifts ranged from .08 to 8.77 and the unfavorable did it from 0 to 3.90. The directions of both kinds of shifts are in the same way. The significant favorable shifts were found to be in Overall 3.05 (p = .056) and in Applied Conceptual Understanding with a shift of 8.766 (p = .009). In the All and Problem Solving Sophistication categories were found shifts of 3.78 (p = .097) and 6.287 (p = .085) respectively.

It is noteworthy that the lowest score in the pre, found in Applied Conceptual Understanding, is no longer the lowest score in the post test. The score in Problem Solving Confidence is the highest in both cases and could be relevant because students, even before instruction, seem to know how to solve problems and they are sure the answers are right. These students are coming from high school, where they have directly used formulas to get answers.

Other thing to note in the results is that all the favorable shifts were found to be positive and all the unfavorable shifts were found to be negative. This means that the entire group has gotten improvements in its perception toward Physics.

The most significant result found in this study is in the category Applied Conceptual Understanding. This result is also the most important found in the study made by Brewe, Kramer, and O'Brien [6] at Florida International University (FIU). Even though both modeling implementations had no relationship between them, other than following the literature about how to make modeling implementations [4, 5], the results are quite similar. Modeling instruction seems to improve the scores in Overall and Applied Conceptual Understanding being independent of the specific implementation. It is important to remember that one of the objectives or premises behind modeling instruction is to bring students to the being of scientists. It looks like a better understanding of the knowledge they get comes together with the methodology and the activities of modeling instruction.

It is interesting that when comparing the pre and post data to the one found in FIU those categories are also similar in the scores. The overall in this study was of 68.35 pretest and 71.40 posttest while the study in FIU is approximately 69 pre test and 78 post test of the equivalent Mechanics course. The All category that takes into account only the categorized questions in the CLASS test gave a pretest of 70.60 and a posttest of 74.39 in this study, which are similar to the 70 pretest and 79 posttest found in FIU.

Some similarities could be found in students attending FIU and Tecnologico de Monterrey, but the authors assume those themselves are not the cause of these positive shifts. Future studies could acquaint for other benefits or forms to improve conceptual learning while making students more like experts.

It is important to remember that the use of non-parametric statistics was needed in this study since the sample was not normalized.

CONCLUSION

Improvements of beliefs and attitudes toward Physics have to be considered in the curriculum development in order to get, at the end of the course, more motivated students with the understanding of the roll that scientists play in society. The CLASS survey is a useful tool to assess the success in an implementation in terms of the improvements of beliefs and attitudes toward Physics. In this study, significant positive shifts were found in two of the categories that the CLASS test assesses. The positive shifts found in this study together with those found in Florida International University show that modeling instruction is able not only to improve conceptual learning, as previous studies widely show, but is also capable of changing students' beliefs about Physics.

Bigger changes could be reached if the intention to improve beliefs in the students were a part of the curriculum development and not only a consequence of the course methodology.

ACKNOWLEDGMENTS

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