Expectancy Violation in Physics and Mathematics Classes in a Student-Centered Classroom

Carolina Alvarado[1], Angeles Dominguez[2], Ruth Rodriguez[2] & Genaro Zavala[1]

1. *Physics Education Research and Innovation Group and Department of Physics*
2. *Department of Mathematics*
Tecnologico de Monterrey, Campus Monterrey
Ave. Eugenio Garza Sada 2501, Monterrey, Nuevo Leon, Mexico

Abstract. This report analyzes the results of the implementation at a large private Mexican university of the Pedagogical Expectancy Violation Assessment (PEVA), developed by Gaffney, Gaffney and Beichner [1]. The PEVA was designed to evaluate shifts of the first student's expectations due to the initial orientation and experiences in the classroom. The data was collected at the Student-Centered Learning (ACE) classroom, based on the Student Centered Active Learning Environment for Undergraduate Programs (SCALE-UP) classroom. Three professors participated with their groups during the first semester they implemented their courses in this environment. Participants were enrolled either in a Pre-Calculus, Differential Equations, or Electricity and Magnetism course. The results indicate shifts in students' expectations during the semester and reveals differences in shifts among the different courses.

INTRODUCTION

The adaptation of the SCALE-UP pedagogy [2, 3] into the Student-Centered Learning classroom (ACE, Spanish acronym) [4] at a large Mexican private university is analyzed. The Pedagogical Expectancy Violation Assessment (PEVA) [1] was applied during the first semester the classes started in the ACE classroom at the university, teaching Pre-Calculus, Differential Equations and Electricity and Magnetism courses. In this report we present the shifts of the students' initial expectations during that semester.

The PEVA was designed to uncover students' initial expectations before starting a reformed pedagogy and to assess the changes due to the instruction. It consists in a set of fifteen items which focuses on salient features of the ACE environment. To achieve a measure of change in PEVA, according to authors [1], the study consists in three stages. In the first stage, the survey is administered before the first class to reveal the initial expectations of students. In the second stage, the survey is administered right after the instructor's introduction to the pedagogy and first activities implementations occur to assess any shift of expectations from their first impressions, we decided to administrate it during the second/third week. For the third stage, which occurs at the end of the semester, the survey is administered after students experience the pedagogy and ACE environment [1].

Also, at the end of the semester, six questions [1] were administered to assess the overall affective success of the pedagogy in the classroom.

The study covers four objectives: 1) assess salient features of the pedagogy in each course, 2) compare the salient features among courses, 3) evaluate overall affective responses in each course and 4) compare the overall affective responses among courses.

In the following section, the methodology of this research is described. Following, the results are discussed focusing on salient features of the pedagogy and overall affective responses of the students. In each section results from individual courses and a comparison among the courses are presented. At the end, the conclusion section summarizes the study and makes the last inferences of the study.

STUDY DESIGN

We implemented a Spanish version of PEVA to assess expectations of students and the change with instruction. The translation was prepared by experts in education research and reviewed after an implementation in a pilot group.

PEVA contains fifteen items, each describing activities in the classroom, which are scored on a 7-point scale based on frequency of occurrence in the classroom, ranging from *very infrequently* to *very frequently*. In the first and second stages students were

asked how often they expected to experience and in the third stage how often they experienced the activities presented on the items. The affective survey consists of six items that are scored with a 7-point Likert scale ranging from *strongly disagree* to *strongly agree* [1].

The first survey was sent to students electronically to answer before the first class. Students who didn't reply to the electronic survey took the survey at the beginning of the first class on sheets of paper. The second (PEVA survey) and third stages (PEVA and affective surveys) were only implemented online and students had one or two weeks to respond.

Data were collected from all three ACE courses during the fall semester of 2010: two sections of Pre-Calculus (PC), three sections of Differential Equations (DE) and two sections of Electricity and Magnetism (EM). PC students were in their first semester while DE and EM students in their third or fourth semester.

Only data from students who responded all three stages of PEVA were considered for the salient features section of the analysis: 104 PC students, 76 DE students and 32 EM students. The second stage of PEVA had a low student response. It may have been caused by the short time spent between the first and second stage. The analysis of the affective questions requires that the student respond to the last stage of PEVA; this resulted on 111 PC students, 171 DE students and 80 EM students.

The data were analyzed by non-parametrical tests using SPSS and Excel. Friedman and Wilcoxon signed ranks tests were used to find differences in medians [5]. Due to the differences in sample sizes from each course, the comparisons between groups were made based on their boxplot.

RESULTS AND DISCUSSION

This section is divided into two subsections which each of them addresses the assessed categories of the survey.

1. Salient Features of the Pedagogy

For this section of the study, students were asked how often they expected/experienced the phrases presented regarding the reformed classroom. The answers presented in a Likert-scale ranging from 1 (*very infrequently*) to 7 (*very frequently*).

We present only some of the items because of space limitation. The initial expectation for item two "A grading curve", in all the courses, showed results in full range of seven with a median of four (the neutral point). Then later, the orientation caused no statistical difference in their expectations (p>.05). However,

after experiencing the pedagogy in the classroom, the *grading curve* results revealed a favorable change (p<.05), that is, that there was no grading curve. PC students continued providing a wide range of seven, but the median decreased to two (*infrequently*). In the case of DE and EM students, the range decreased to three having a median of one (*very infrequently*). In all the courses there is statistical evidence of change from expectations to experience in the *grading curve* item due the course.

On the other hand, item nine "To memorize equations" did not show any statistical change at any stage (p>.05). In all the courses the range remained at seven. PC students' answers had a median of five (*somewhat frequently*), with the middle 50% of students choosing from four to six. DE students' answers had a median of four (*sometimes*) with the middle 50% of students choosing from two (*infrequently*) to six (*frequently*). Similarly, EM students' answers had a median of four, *sometimes*. This item reveals that the reformed pedagogy in its first semester of implementation had no change in students' idea that memorizing equations was part of their responsibility, differing from SCALE-UP results [2] in which students stated they felt they were learning at a deeper conceptual level and they have less rote memorization.

In each course, the items regarding collaborative discussion and discussion of their work with classmates during class time showed favorable and significant change (p<.05). The original expectancies in both items showed a median of five (*somewhat frequently*), then, after experience, the results show that at least 50% of the students chose the answer *very frequently* in each course.

We use the boxplot representation to analyze some students' answers distribution. Figure 1 shows the answers' distribution for the item "Collaborative (group) discussions" in the three different stages of the survey. From left to right we present the answers with the PC, EM and DE courses. We observe that the initial expectations have a large range of answers for the three courses. For instance, the boxplot of the initial survey for PC students show that the median is 5, the upper and lower middle quartiles range from 5 to 6 and 4 to 5 respectively and the lower quartile has the largest range. After the initial orientation, students' expectations increased. Then in the third stage, DE and EM students changed their after-orientation-expectations to what they experienced. Most of the students reported an elevated level of collaborative discussion. The particular case of EM students reveals that, besides two outliers (numbers indicate the number position on the data list), all students experienced collaborative discussions very frequently.
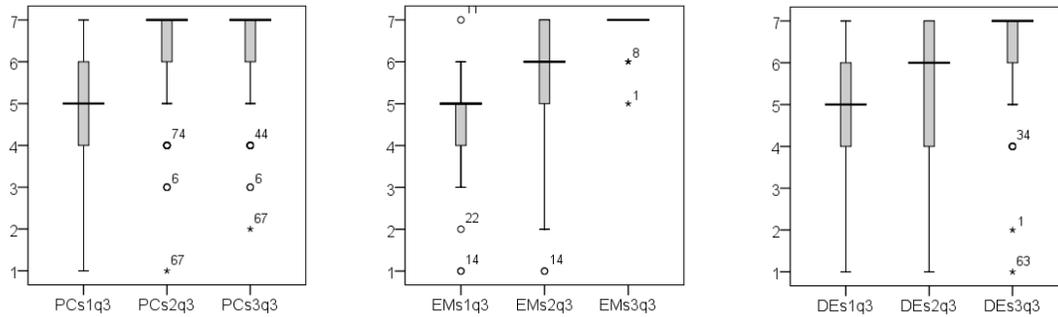
FIGURE 1. Boxplots of students' answers about collaborative (group) discussions for the three survey stages among the courses.

The team work promotion, one of the main purposes of ACE environment, is achieved by the high interaction level students experienced. Answers to item 12, "To interact with my peers during class time", reveal that even though students initiate their course with high expectations to interact with their peers (a median of six, *frequently,* in all courses), the most desirable shift from expectations to experience interaction with peers is presented in every course (see fig. 2). All the students from all the courses, except the outliers, reported they had experienced interaction with their peers *very frequently*. Students felt at the end that ACE made them discuss more than what they expected. Another interesting outcome is that even in the initial students' expectations; the results showed these students expect more interaction than those in another study in the US [1].
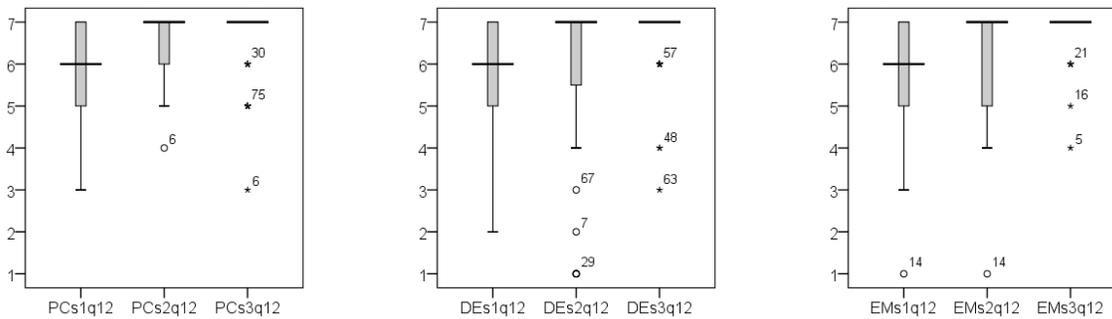
FIGURE 2. Boxplots of students' answers to their expectancy about team work for the three survey stages among the courses.

However, the results, related to interaction and discussion with professors, do not have similar performance to what is obtained in the previous item. Students' initial expectations have no statistically significant change (p>.05) with respect to the interaction and discussions with their professor and TA. The course sections in the subject university usually have an average of 35 students. ACE courses have approximately twice this number. Usually one professor is in charge of the traditional section, but in ACE courses there is also a teacher assistant (TA). Therefore, having a TA may be influencing the results.

Item 10, "To interact with my instructor during class time", had high students' expectations from the beginning. The median remained among the courses and stages between a frequency of six (*frequently*) and seven (*very frequently*). Meanwhile, item 15, "To discuss my work with my instructor or TA during class time", answers were from five, *somewhat frequently,* to six, *frequently*. In those cases students' expectations were not violated. After looking at the results regarding group discussion and interaction with peers, it was expected to have a shift indicating the important role that professors and TAs play in students' interactions, but students' expectations did not change. However, the initial expectations were high compared to those in another study in the US [1]. This may be due to the somewhat spread use of collaborative strategies in the Institution.

2. Overall Affective Success

The *overall affective success* survey was administered along with the third stage of the PEVA. Students are asked to indicate the extent to which they agree with the sentences presented in a Likert-scale from one, s*trongly disagree,* to seven, *strongly agree*; with four as a neutral point. In this subsection, we report the analysis of four sentences. This survey

revealed a wide variation of results, a range from one to seven in all items, except one case in one course.

Figure 3 shows the boxplots of the first four sentences of the survey. Sentence one "The ACE environment is a useful style of teaching and learning" in mathematics courses (PC and DE) had agreement from at least 50% of students. Meanwhile, at least 75% EM students agreed.
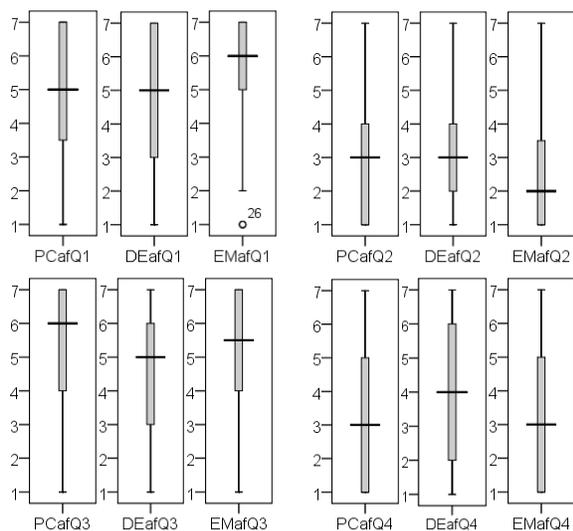
FIGURE 3. Boxplot representation of students' overall affective answers. The answers correspond to PC, DE and EM courses from left to right in each triad. The results are presented from sentence one at the top left to sentence four at the bottom right.

In all courses, at least 75% of students answered from neutral to disagreement with item two: "The ACE environment is inappropriate for college classes." Similarly, at least 50% of them, in each course, agreed with item three: "Courses in other departments should use an ACE environment." A remarkable 50% of PC students selected *agree* or *strongly agree* for this item.

The fourth item was a negative statement related to students' personal choices: "ACE is not for me." The results for this item showed the most extended variation. DE students had a median in neutral choice and a symmetric distribution between agreement and disagreement, showing no tendency at all. On the other hand, PC and EM students had a median of three, (*somewhat disagree*) the weakest level of disagreement, having not much tendency to show a difference with DE students.

Because of the wide ranges of results in this survey, it cannot be strictly assured the success of the ACE reformed pedagogy in its first semester of implementation. Nevertheless, it is important to notice that for all items most of the students answered from the neutral to the favorable extent of agreement.

CONCLUSIONS

In first-time implementation of ACE in mathematics and physics courses, students reported frequent collaborative discussions with their peers, as well as other interactions with their peers during class time. Even though the ACE capacity almost doubles the usual classroom capacity, the interaction with professors did not differ from what they expected (high expectation) to what they experienced. This could be seen as positive results. Some SCALE-UP salient features were not achieved, like the unchanged perception to memorize equations in all courses. However, for a first-time implementation of this pedagogy, the results are positive.

Overall affective answers reveal students have a wide range view of how ACE worked out for them. For every affective item, at least half of the students gave neutral to desirable agreement responses. We think that students are used to being left alone in a traditional classroom, but in this room, there was no option, and the activities were designed for students two work on them collaboratively.

ACKNOWLEDGMENTS

REFERENCES

1. J. Gaffney, A. Gaffney, and R. Beichner, "Do they see it coming? Using expectancy violation to gauge the success of pedagogical reforms," in *Phys. Rev. ST Phys. Educ. Res.,* **6** (1), 010102 (2010).
2. R. Beichner, J. M. Saul, D. S. Abbott, J. J. Morse, D. L. Deardorff, R. J. Allain, S. W. Bonham, M. H. Dancy, and J. S. Risley, "The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) project," in *Research-Based Reform of University Physics*, edited by E. F. Redish and P. J. Cooney (American Association of Physics Teachers, College Park, MD, 2007), Reviews in PER Vol. 1.
3. J. Gaffney, E. Richards, M.B. Kustusch, L. Ding, and R. Beichner, "Scaling up education reform,"*Journal of College Science Teaching,* **37** (5), 18-23 (2008).
4. G. Zavala, H. Alarcon, A. Dominguez, and R. Rodriguez, "Sala ACE: Tecnologia al servicio de la educación", in *Ciencia Conocimiento Tecnologia*, 110, 36-40 (2010).
5. R. Hernández, C. Fernández and P. Baptista, *Metodología de la investigación*, 4 ed. (McGraw Hill, México, 2006).