Learning STEM: Graphs vs. Equations

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Students' understanding of graphs in physics has been extensively studied due to its importance in their education across disciplines. Our study began two years ago as research on Scholarship of Teaching and Learning regarding an exercise in Simple Harmonic Motion within large general physics lecture courses. In particular, our study focused on which approach, graphical or mathematical, would lead to higher scores in written examinations. Students are from second-year engineering programs.

Outcomes:
Understand clearly the context of this study.

Describe what the objective of the research was.

Identify what the common mistakes are among the students from both approaches.

Summarize the difficulties that students face in solving these exercises, as well as the effects on exam scores.

Category: Research
Indicate your teaching and learning project: the problem, question, or opportunity addressed in your paper and why it was a problem or opportunity; Describe what you saw in your students', colleagues', or institution's behavior that you wanted to change. Describe the learning objectives you wanted students or colleagues to better achieve as a result of your project.
In fall 2011, the regular course of general physics, Heat and Wave, changed from 24 for students to large lecture courses averaging 80 to 120. During the first 2 semesters with these new groups, they were taught in the traditional way; however, the percentage of students who dropped out or failed these courses increased considerably. To explore the students' opinion, we asked them to complete a survey regarding the classroom environment of these courses. Students do comment that they find it difficult to participate in large lecture courses and they feel that their professors in these courses do not know them. Therefore, theses
courses became a pedagogical challenge. Then, for 2012, the first action was to tackle the passive role of the students, and to complement that, clickers were introduced. The second aspect was to foster student engagement through the implementation of creative pedagogical approaches (Rada, 2015). The third aspect came late, two years ago, and it is related to trying to find answers about how students come up to some key topics inside the education processes for engineering programs. One of them is the Simple Harmonic Motion (SHM). Thus, this study began as research on Scholarship of Teaching and Learning (Bishop-Clark & Dietz-Uhler, 2012) regarding an exercise in SHM within large general physics lecture courses.

If your project involved a particular course or curriculum, briefly describe it, its students, and its place in the curriculum or program.

The project involved large lecture courses of General Physics, Heat and Wave, which is a basic course from second-year engineering programs at Universidad del Norte, Colombia.

How did you solve the problem, answer the question, or address the opportunity? How is your approach different from ones that others have tried?

Uninorte launched an initiative for 2012-2013 aimed at promoting change in the teaching strategy of those professors of large lecture courses, specifically geared to promote active and meaningful student learning. Under this initiative, we started to implement some methodological changes (Fink, 2003) that will be oriented to help the class environment and the interaction (student–teacher and student–student), but also to improve the students´ global scores and to decrease the percentage of students who drop out or fail this course. Until this point, we can say that all changes will lead to achieve better conditions in the classroom, to benefit the students´ self-confidence, and, in turn, to promote active learning (Bonwell, 1991). Related to the research question on the SHM, we considered two exercises, graphical approach and mathematical approach, which were statistically equivalents, and with the same teacher. Some previous work on SHM have pointed out the relevance in the introduction of this topic (Roche, 2002); in contrast, the present work relies on the comparative analysis of the students' answers when two approaches are presented. In addition, even when many researchers have studied the effect of the graphs in physics, mostly they have focused on kinematic physics (McDermott, Rosenquist, & van Zee, 1987; Beichner, 1990; 1994) or in other contexts (Planinic, Ivanjek, Susac, & Milin-Sipus, 2013). Here we use another line, which is related to the periodic behavior of many physical situations.

Assessment and baseline: Indicate how you determined the success and effectiveness of your project. You may use quantitative or qualitative data or both.

The success of this project can be presented in different ways, such as: (1) Students’ opinions
through an anonymous clickers session in the third month of each semester (2012-2013), where the questions presented are oriented towards the methodology changes introduced in the course, and to know how beneficial the clickers' sessions were; (2) a Quick Course Diagnostic (QCD) for each semester, which was conducted in order to know the students´ opinion about the satisfaction level of the learning experience from the course.

On the other hand, the effectiveness of the research question concerning the SHM theme can be presented from both the quantitative and qualitative data, which were collected from results of the students´ written examinations in open-ended questions or exercises. We should mention that exercises were designed to be presented in a mathematical way or in a graphical way. One exercise (for example a equation with some values) was included in Test labeled A, and the other type of exercise (for example a graph with numerical labels) was included in test labeled B. Students had to solve randomly either Test A or B. The student's answers were collected and organized as standard way.

References:


Planinic M., Ivanjek L., Susac A., & Milin-Sipus Z. (2013), Comparison of university students' understanding of graphs in different contexts, PHYS. REV. ST PHYS. EDUC. RES. 9, 020103

Organization:

First, I will introduce the topic by asking the participants how big their lecture courses are in order to establish a common context through which to understand the study. I will conduct an informal poll to find out what fields of study the participants represent, as well as which approach, graphical or mathematical, they prefer when presented with an exercise in science.

Next, I will present the study and its implications. This will include a demographic overview of the students, university, and region in question, as well as an illustration of the specific classroom context in which the study was conducted. Using PowerPoint, I will present the core of the study, including a concise explanation of the research question, and the two approaches to analyzing Simple Harmonic Motion that we used in our study. This will be followed by a summary of the results obtained and possible causes of the difficulties that students face in identifying variables and extracting information from the graphs and equations.

Keywords:

Class Participation
Large Classes
Learning Styles
Scholarship of Teaching and Learning (SoTL) Example
Science Pedagogy
STEM