Tracking Student Persistence on the Force Motion Conceptual Evaluation

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Abstract: The persistence of students' holding onto a misconception has not fully been studied. This study examined Force Motion Conceptual Evaluation (FMCE) data from 1600 high school and college students. Students show a commonality in the ideas they held at both the high school and college level but did not show learning gains. Students did demonstrate a high level of purposeful choice selection as demonstrated by a 40-60% persistence in choice maintenance.

Keywords: Persistence, FMCE, No Learning Gains

1. Introduction

The problem of students' personal misconceptions as barriers in learning have always existed in education. Many studies have been conducted to expose, flush out, or examine these misconceptions. While the idea of understanding these misconceptions has been highly researched and discussed there has yet to be a consistent methodology in exploring them. (Wolff-Michael, 1997) It is for this reason that the research vetted methodologies for assessing students simply focused on did students' master a concept. (Davenport, 2008) The two most frequently utilized assessments in Physic's Education research are the Force Motion Concept Inventory (FCI) and the Force Motion Conceptual Evaluation (FMCE). Both tests have demonstrated a normalized gain of ~15-20% when traditional instruction is used versus ~55-60% gain with research based instructional environments. (Thornton R., 2009) (Wells M, 1992) (Thornton, 1998) These instruments demonstrate the ability of a student to correctly select a single answer from a multiple choice answer bank. In most circumstances instructors use this feedback to calculate gains and in a more detailed context track each student's progress. (Halloun, 1985)

While this data shows student achievement it does not account for subtle variances in student understanding within a given field. The data traditionally collected is not typically analyzed to see if it is skewed towards a certain selection methodology for incorrect answers. Additionally few published studies have attempted to track the individual student's persistence in the selection of certain answer choices. These questions were not initially at the forefront of our group's research but upon the completion of the two-year study it became an area of great interest.

2. Methodology

The data for this experiment was collected over a two-year period and involved five different classroom settings. Four of these classrooms were at a high school and one was at a four-year state university. Two years of data was collected at a suburban high school in southern Louisiana. The high school data was collected from all of the ninth graders who were enrolled in a state mandated physical science course. The course was taught using the Louisiana State Grade Level Expectation Standards and followed a time period that was allotted per the state and local parish's "pacing guide" of instruction. The time allotted for Newton's Laws and Kinematics was two full weeks. (Louisiana Department of Education) There were seven specific topics that were addressed in a ten-day instructional period, with each session totaling fifty-five minutes in duration. These seven were:

Science Grade-Level Expectations: Physical Science (Recommended for Grade 9) Forces and Motion

A.) Differentiate between mass and weight (PS-H-E1) B.) Compare the characteristics and strengths of forces in nature (e.g., gravitational, electrical, magnetic, nuclear) (PS-H-E1) C.) Differentiate between speed and velocity (PS-H-E2) D.) Plot and compare line graphs of acceleration and velocity (PS-H-E2) E.) Calculate velocity and acceleration using equations (PS-H-E2) F.) Demonstrate Newton's three laws of motion (e.g., inertia, net force using F = ma, equal and opposite forces) (PS-H-E3) G.) Describe and demonstrate the motion of common objects in terms of the position of the observer (PS-H-E4)

The teachers participating in this study were all teaching for more than five years prior to the study' start date and each was considered "highly qualified" by the state of Louisiana. The teaching styles of the four high school level teachers were varied and did not follow any preset lesson or methodology. Each educator was able to utilize the same textbook, teacher textbook resources, textbook test bank, lab equipment, and instructional technology. Some teachers collaborated on using the same laboratory setups/resources, but it was not required by the school district or state for labs to be used in the instruction of this unit. The FMCE pretest was given in a one hour session prior to any instruction and the post test was given in a one hour session immediately following the conclusion of instruction.

The college portion of the study was conducted in an Introductory Physics course. The course was a one-semester class and covered measurement, vectors, kinematics, Newton's laws of motion, and energy. The college portion's data was collected within the same academic year but in two different terms. The instructor of the course was given carte blanche in course design, instructional methodology, and demonstration utilization. The instructor for this course was a former high school teacher and self reported using team interactions, white boarding, and clicker questions to make the course less lecture based and to foster student interactions. Both sets of college participants took the FMCE on a computer based testing program. The pretest was given prior to the course's instruction beginning and the post-test was given at the conclusion of the semester. The college portion of the study was tested after a sixteen week period.

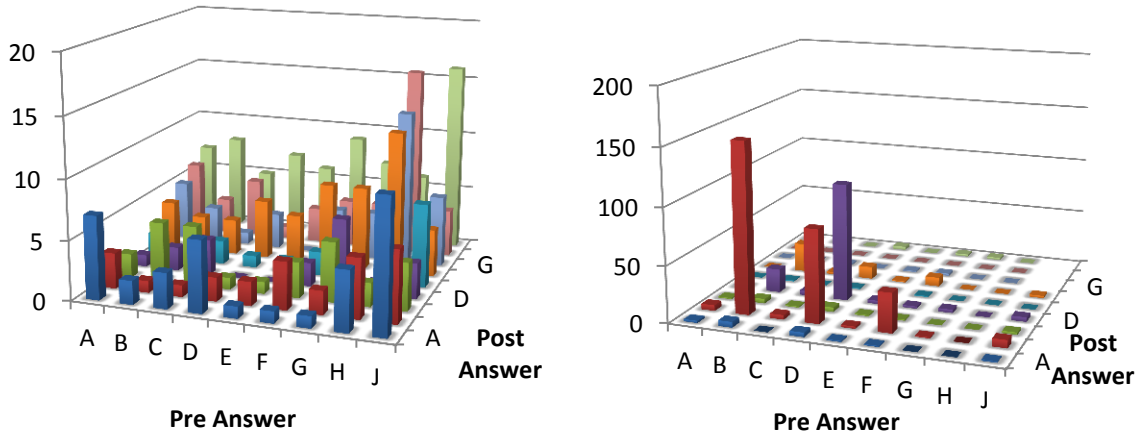

Figure 1: A two-dimensional histogram of the answers of students on the FMCE from high school (left panel) and college (right panel) on a single question. The more common observances for the college data tended to be correlated as the right panel shows. The high school data fluctuate between the two panels . See discussion in the text.

3. Results

1600 participants' data was analyzed for this study. The random guessing threshold for the FMCE is seven questions. The high school average pretest score was six and posttest score was seven questions. The average college pretest score was nine questions and posttest was twelve questions. When the test data was analyzed for the four high school teachers there was no statistically significant difference in their scores. There was a slight statistical difference between the college and high school groups. The left (right) panel of Fig. 1 displays the number of high-school (college) students that choose a given pre and post answer for question # of the FMCE. For example, the height of the histogram bar at point (A,A) is the number of students who chose answer A for both the pre and post-test. The persistence of student selection of answers varies from question to question. In both high school and college groups the same common misconception answer patterns were selected by a majority of students for many of the questions (see Fig. 1). Students tended to follow two patterns of responding. In one pattern they narrowed their selections to either two or three answer choices (right panel in Fig. 1). In the other model students were persistent in their selection of a choice but it was distributed between many different choices (left panel in Fig. 1).

4. Conclusion

The study showed that there was a decided persistence of 40-60% for students to maintain their response, whether it was correct or incorrect. The data showed that there was a slight difference in the content mastery between the college and high school students of about 8%, or 4 questions. The preliminary data appears to show that student misconceptions are firm and not easily altered by teaching style or duration of teaching time. The preliminary data also indicates the need for a more in depth statistical analysis. This study also prompts the need for a more in depth analysis of the time frame and instructional techniques used to cover these concepts.

5. Acknowledgments

The current work is funded by the NSF EPSCoR LA-SiGMA project under award #EPS-1003897 and the LaMSTI Program NSF award #DRL 0928847.

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