Comparing Learning in a MOOC and a Blended On-Campus Course

Kimberly F. Colvin
MIT, 26-331
77 Mass. Ave
Cambridge, MA 02139
617 324-4528
colvin@mit.edu

John Champaign
MIT, 26-331
77 Mass. Ave
Cambridge, MA 02139
617 324-4528
john.champaign@gmail.com

Alwina Liu
MIT, 26-331
77 Mass. Ave
Cambridge, MA 02139
617 324-4528
alwina@mit.edu

Colin Fredericks
MIT, 26-321
77 Mass. Ave
Cambridge, MA 02139
617 324-4528
colin.fredericks@gmail.com

David E. Pritchard
MIT, 26-241
77 Mass. Ave
Cambridge, MA 02139
617 253 6812
dpritch@mit.edu

ABSTRACT

We studied student learning in the MOOC "Mechanics ReView", run on the edX.org open source platform as 8.MReV. We administered 13 conceptual questions both before and after the instructional period, analyzing the results using standard techniques for pre - post testing. Our students had a normalized gain slightly higher than typical values for a traditional course but lower than typical values for courses using interactive engagement pedagogy. All questions in the MOOC, including the pre-post test questions were analyzed using Item Response Theory (IRT). Both the normalized gain and the IRT results showed that initially low-skill cohorts learned as much as all cohorts with higher initial skills. We were able to compare MIT freshmen taking an on-campus course with the 8.MReV MOOC students because many common problems were administered to both groups. The freshmen were considerably less skillful than the 8.MReV students and showed no signs of closing the gap with the more experienced 8.MRev students while covering topics in common with the MOOC.

Keywords

MOOC, edX, Item Response Theory, learning gain

1. INTRODUCTION

The recent release of hundreds of free online courses in MOOCs (Massive Open Online Courses) by organizations such as coursera.com, edX.org, and udacity.com has been so dramatic that an article in the New York Times proclaimed 2012 the "Year of the MOOC" [4]. A central question remains: "is there learning in MOOCs?"

In this paper, we report an initial study of learning in a MOOC, 8.MReV – Mechanics ReView – offered from June 1 to August 27, 2013 on the open source platform edX.org. The course materials were written by the RELATE education group (REsearch in Learning, Assessing, and Tutoring Effectively, http://RELATE.MIT.edu). This is a "second course" in introductory Newtonian Mechanics, designed to help students familiar with the topic at a high school level gain a more expert-like perspective on the subject. In addition, we made a concerted effort to attract high school physics teachers to enroll in our course.

We used two major approaches to evaluate learning in a MOOC: (1) a pre- and posttest analysis on an identical set of, mostly conceptual, questions [5] and (2) an analysis of the overall and topic-by-topic performance using Item Response Theory (IRT). Given that the on-campus students also benefitted from four hours of instruction in a flipped classroom, we addressed the question of whether their skills increased week by week relative to those of the MOOC students.

2. DATA

2.1 Description of MOOC: 8.MReV

The 8.MReV course grew from a short Mechanics ReView course run at MIT, which used an online eText and pre-class homework questions. For the MOOC, these online materials were augmented by additional problems and weekly quizzes. The 8.MReV course studied here involved was delivered via the edX.org platform and in the summer of 2013 with both general and teacher-targeted publicity. The 1080 students who attempted more than half of the problems were included in this study.

2.2 Description of On-Campus Course: 8.011

The on-campus course, 8.011, is the spring version of Introductory Newtonian Mechanics at MIT. This subject, together with the subsequent Electricity and Magnetism course, are required of all MIT graduates, and most take it in their first semester. Students who earned less than a C in mechanics course required to retake the course before moving on to Electricity and Magnetism; these students make up about 80% of the population of 8.011. In Spring 2013, there were 47 students in 8.011, the first time the online segment of the course was run on the edX.org platform rather than LON-CAPA. Of these 47 students, 35 attempted more than half of the online problems. These 35 students were used in this study.

3. Pre-Post Testing in the MOOC

The pre- and posttests consisted of 15 questions, three of which came from the Mechanics Baseline Test [3] and four were from the Mechanics Reasoning Inventory [4]. These fifteen questions focused on conceptual knowledge more heavily than algebraic ability. The results were analyzed in terms of the fractional reduction in the number of incorrect answers on the pretest as measured by the posttest. This quantity is referred to as the normalized gain by Hake [1].

4. Item Response Theory (IRT)

IRT places students and items on the same scale, taking into account a student's specific performance on each item [2], even when students do not take the same set of items. Each item's difficulty and discrimination is taken into account. IRT stands in contrast to classical test theory whose unit of analysis is the entire test, usually graded by the total number of items correct.

5. PRE AND POST TEST RESULTS

The pre-posttest analysis was performed on several sets of questions, here we will report on two: (1) six questions involving force and motion that could be compared with Hake's study [1] and (2) five questions on more advanced topics.

Traditional analysis of pre-post testing requires students to have done all questions in that set on both tests, which limits the number of students in each cohort. The IRT-based pre to posttest change was a statistically significant increase for the 579 students who took at least 7 pre and posttest items.

We observed learning as measured by normalized gain that are greater than the traditional courses studied by Hake [1] (0.23) and less than the interactive courses (0.48). While both of our gains, 0.30 and 0.33 (+/-0.02) are closer to the traditional on-campus courses, they lie above *all* of the 14 traditional classes studied by Hake, suggesting that our students learn conceptual topics slightly better than in a traditional, lecture-based, class. When we examined the normalized gain for various cohorts, it is significant that we saw no cohorts significantly below or above the normalized gain for the whole group. This certainly should allay concerns that less well prepared students can't learn in MOOCs.

6. COMPARISON OF SKILLS BY COHORT

The skill distribution for all 8.MReV students has a mean of 0 and a standard deviation of 1, for convenience. Using the same scale, the teachers have a mean of 0.39 and a standard deviation of 0.97. The on-campus 8.011 students' skill averaged about one standard deviation below (-1.05) the overall average in 8.MReV and had less variation with a standard deviation of 0.50. In retrospect, this may not be surprising as the average 8.MReV student is better educated, older, and not juggling three or four other MIT courses.

We compared the topic-by-topic skills of various cohorts: teachers, on-campus students, strong background in mathematics, for example. In this analysis we were not looking at their absolute skills, which we knew to be different, but rather the pattern of the change in skills from one topic to the next. We wanted to know if perhaps a weaker cohort in terms of their overall skill, showed marked improvement throughout the course, for example. However, none of the cohorts showed a significant linear improvement across the topics.

7. CONCLUSIONS

It is also important to note the many gross differences between 8.MReV and on-campus education. Our self-selected online students are interested in learning, considerably older, and generally have more years of college education than the on-campus freshmen with whom they have been compared. The on-campus students are taking a required course and also had many ways to obtain help on the problems in addition to four hours of highly interactive class time. Moreover, there are more drop-outs in the online course (but over 50% of students making a serious attempt at the second weekly test received certificates) and these may well be students learning less.

In this MOOC, there was significant learning for the students studied here, in fact, slightly more than students in a traditional, lecture-based, on-campus classroom**.** It is also noteworthy that analyses of the pre-post testing using normalized gain and IRT approaches both provide evidence that students throughout the wide range of abilities in our course, including those of low ability, learn a comparable amount.

8. ACKNOWLEDGMENTS

We acknowledge support from a Google Faculty Award, MIT, and NSF. We thank Yoav Bergner for thoughtful comments on the manuscript.

9. REFERENCES

[1] Hake, R.R. 1998. Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*. 66 (1), 64-74.

[2] Hambleton, R. K., Swaminathan, H., & Rogers, H. J. 1991. *Fundamentals of item response theory*. Newbury Park, CA: Sage Publications.

[3] Hestenes, D. & Wells, M. 1992. A Mechanics Baseline Test. *The Physics Teacher*, 30, 159-165.

[4] Hestenes, D. Wells, M., & Swackhamer, G. 1992. Force Concept Inventory. *The Physics Teacher,* 30, 141-158.

[5] Pappano, L. (2012, November 2). The year of the MOOC. *The New York Times.*

[6] Pawl, A., Barrantes, A., & Pritchard, D. 2009. *Modeling Applied to Problem Solving.* Proceedings of the 2009 Physics Education Research Conference, M. Sabella, C. Henderson and C. Singh, (Eds.) pp. 51-54

[7] Pritchard, D. E., Lee, Y. J., & Bao, L. 2008. Mathematical learning models that depend on prior knowledge and instructional strategies. *Physical Review Special Topics-Physics Education Research*, *4*(1), 010109.