Paper ID #19032

NSF PRIME Project: Contextualized Evaluation of Advanced STEM MOOCs

Dr. Kerrie A Douglas, Purdue University, West Lafayette (College of Engineering)

Dr. Douglas is an Assistant Professor in the Purdue School of Engineering Education. Her research is focused on methods of assessment and evaluation unique to engineering learning contexts.

Prof. Heidi A. Diefes-Dux, Purdue University, West Lafayette (College of Engineering)

Heidi A. Diefes-Dux is a Professor in the School of Engineering Education at Purdue University. She received her B.S. and M.S. in Food Science from Cornell University and her Ph.D. in Food Process Engineering from the Department of Agricultural and Biological Engineering at Purdue University. She is a member of Purdue's Teaching Academy. Since 1999, she has been a faculty member within the First-Year Engineering Program, teaching and guiding the design of one of the required first-year engineering courses that engages students in open-ended problem solving and design. Her research focuses on the development, implementation, and assessment of modeling and design activities with authentic engineering contexts.

Prof. Peter Bermel, Purdue University

DR. PETER BERMEL is an assistant professor of Electrical and Computer Engineering at Purdue University. His research focuses on improving the performance of photovoltaic, thermophotovoltaic, and nonlinear systems using the principles of nanophotonics. Key enabling techniques for his work include electromagnetic and electronic theory, modeling, simulation, fabrication, and characterization.

Dr. Bermel is widely-published in both scientific peer-reviewed journals and publications geared towards the general public. His work, which has been cited over 4400 times, for an h-index value of 24, includes the following topics: * Understanding and optimizing the detailed mechanisms of light trapping in thin-film photovoltaics * Fabricating and characterizing 3D inverse opal photonic crystals made from silicon for photovoltaics, and comparing to theoretical predictions * Explaining key physical effects influencing selective thermal emitters in order to achieve high performance thermophotovoltaic systems

Dr. Krishna Madhavan, Purdue University, West Lafayette (College of Engineering)

Dr. Krishna Madhavan is an Associate Professor in the School of Engineering Education. In 2008 he was awarded an NSF CAREER award for learner-centric, adaptive cyber-tools and cyber-environments using learning analytics. He leads a major NSF-fundedprojectcalled Deep Insights Anytime, Anywhere (http://www.dia2.org) to characterize the impact of NSF and other federal investments in the area of STEM education. He also serves as co-PI for the Network forComputationalNanotechnology (nanoHUB.org) that serves hundreds ofthousandsof researchers and learners worldwide. Dr. Madhavanserved as a Visiting Researcher at Microsoft Research (Redmond) focusing on big data analytics using large-scale cloud environments and search engines. His work on big data andlearninganalyticsis also supported by industry partners such as The Boeing Company. He interacts regularly with many startups and large industrial partners on big data and visual analytics problems.

Nathan M. Hicks, Purdue University, West Lafayette (College of Engineering)

Nathan M. Hicks is a Ph.D. student in Engineering Education at Purdue University. He received his B.S. and M.S. degrees in Materials Science and Engineering at the University of Florida and was formerly a high school mathematics and science teacher.

Mr. Taylor V. Williams, Purdue University, West Lafayette (College of Engineering)

Taylor Williams is a Ph.D. student in engineering education at Purdue University. He is currently on an academic leave from his role as an instructor of engineering at Harding University. While at Harding he taught undergraduate engineering in biomedical, computer, and first-year engineering. Taylor has also worked as a systems engineer in industry. Taylor received his master's in biomedical engineering from Tufts University and his bachelor's in computer engineering and mathematics from Harding University.

Contextualized Evaluation of Advanced STEM MOOCs

Abstract

While it is well-known that massive open online courses (MOOCs) attract large numbers of learners with few completing them, less is known about how to evaluate MOOCs and what metrics are appropriate in open online educational environments. The openness of the MOOC environment presents major challenges to understanding how or what type of learning is occurring and whether the pedagogies used are particularly effective. Furthermore, little is known about the many MOOC users and what they hope to gain, and whether they actually achieve their learning goals. The primary research goal of this NSF-funded project is to provide theoretical foundations for evaluation of online learning environments and increase the capacity for science, engineering, technology, and mathematics (STEM) MOOC evaluation and research. This project focuses on the following research questions: (1) What constructs contribute to learners' behavior in advanced STEM MOOCs? (2) What stakeholder needs inform their decisions in offering and designing advanced STEM MOOCs? and (3) What is a context sensitive, generalizable framework of evaluation for advanced STEM MOOCs? To answer these research questions, we triangulate information from: stakeholder interviews, surveys of learners, and learner analytics.

Introduction

Massive open online courses, or MOOCS, have caused much discussion in both media outlets and academic journals. NSF and other funding agencies (e.g., Hewitt Foundation) have invested millions of dollars in support of college level courses being offered for free or low-cost to anyone with internet access. The openness of the courses, high enrollment numbers, and heterogeneity of learners in any given course have complicated how to make sense of the value of offering MOOCs, both on the individual course level and the overall impact of MOOCs. Because of the openness of the course and large numbers of enrollment, MOOCs present major challenges to the educational evaluation community. In particular, there have been concerns regarding what type of evaluation metrics are applicable for a MOOC environment. Nonetheless, it may be possible to address these concerns with a thorough understanding the contexts of courses, learners, and stakeholders. The first challenge is to make sense of who is utilizing the MOOCs, and for what purposes. The openness of MOOCs invites learners from diverse backgrounds, which may or may not include the prerequisite knowledge, motivation, and time commitment. The result is a largely anonymous set of users, for whom traditional educational evaluation indices have little meaning. Traditional metrics such as drop, fail, and withdrawal percentages have little to no evaluative utility when many learners have no intention or motivation to complete courses in a traditional fashion. At the same time, outcomes of learners who actually wanted to fully engage may get lost among all those that did not. Likewise, descriptive statistics, such as course means, materials accessed, grades, and completion rates simply do not describe the diversity of interest, intent, behavior, and learning.

Another major challenge to making sense of the value of offering MOOCs are the potentially competing stakeholder goals. The major MOOC platforms were formed out of desire to make access to educational content open, yet little evaluative information is available to help determine the success of any given course offering or to foster continual improvement. Instructors and universities partnering with MOOC platforms likely have different goals for MOOCs than widespread awareness. Furthermore, instructors themselves may vary as the topics taught range from very general to specialized engineering content. In the case of advanced STEM-content MOOCs, or content typically taught in upper level or graduate STEM fields, there are significant, specialized prerequisite knowledge (*e.g.,* calculus, differential equations) assumptions of the learner. Therefore, it is expected that advanced STEM MOOCs enrollment would be far lower than MOOCs on introductory-level topics. Yet, for those working in a variety of settings, there is to directly apply the new information to on the job projects, which could increase the overall value of having access to the content. These examples illustrate how course and stakeholder context can affect what data should be collected and how it should be interpreted in non-trivial ways.

Evaluation fundamentals begin with a stakeholders' needs assessment[1]. The success of a course should be evaluated based on the extent to which the needs of the stakeholders have been met in addition to learning outcomes, as they have meaning to the learner. Following that, we understand that institutional, learner, instructor, and course information is needed to contextualize any evaluation conducted in an advanced STEM MOOC. Figure 1 shows the Contextualized Evaluation Framework. The Contextualized Framework emerges from our hypothesis that learner characteristics (e.g. intentions for learning content, level of preparedness for content, current career state, socio-economic demographics, etc.) and course characteristics (e.g. content, pedagogy, instructional design) influence learner behavior and ultimately the learning outcomes in an advanced STEM MOOC. The overall value of the outcomes is determined by the learner and stakeholder goals. The overarching goal of the Contextual Evaluation Framework for Advanced STEM MOOCs project is to provide deep theoretical foundations for evaluation in online learning environments and increase the capacity for science, engineering, technology, and mathematics (STEM) MOOC evaluation and research. To develop the evaluation metrics necessary for contextualized advanced STEM MOOC evaluations, the significant stakeholders, learner, and course variables must be identified through research. The specific project goals are: (1) to identify the stakeholder goals and information needs, (2) to identify the contextual learner and course characteristics that contribute to learner behavior, (3) to develop the metrics needed to assess learner and course characteristics in an online learning environment, and (4) to iteratively test the theoretical framework of how learner and course characteristics are related to evaluation outcomes.

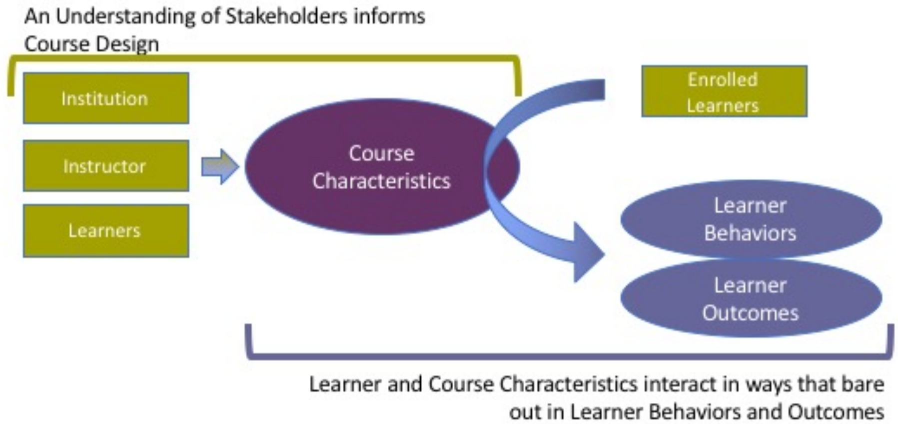

Figure 1. Contextualized Evaluation Framework

Stakeholder Goals and Information Needs

Year 1 stakeholder need assessment activities focused on understanding instructor reasons and intended outcomes from teaching STEM MOOCs and the learning needs of STEM MOOC participants. Our team recruited STEM MOOC instructors identified through major MOOC platforms, and conducted 17 semi-structured interviews, each lasting 45 – 60 minutes. The interviews were focused on three aspects: (1) instructors' approach to pedagogy, (2) primary reason for teaching a MOOC, and (3) what information would be useful to support teaching and evaluate the experience. The key outcome from the interviews is the identification of evaluation criteria that would be meaningful to instructors. From this identified criteria, we will develop metrics to assess the degree to which each criterion has been met and together, will form a rubric for MOOC evaluator use.

Our interview results indicate that STEM MOOC instructors generally have a strong desire to make their content available to learners that will utilize it[2]. Much publicity has been given to the fact that few actually complete a MOOC - yet the small percentage of completers may be the intended audience who value the course content most highly. Not all learners, browse or sporadically utilize materials, yet MOOC literature overall tends to downplay the learners that utilize the materials in a more consistent, traditional course manner. While many acknowledged the mass of learners, and the difficulty of interacting with all of them, they were often quick to talk about individuals they felt benefitted from the course materials. One instructor put it this way, *"He [student] would never have been exposed to quantum physics at such a young age [without the MOOC]."*

Another preliminary finding is that STEM MOOC instructors value providing access to technical content that learners otherwise would not have. One example of this was stated as a question, *"What do the active learners, the people who are submitting everything and really active, what kinds of things are they doing versus people who are more kind of tourists?"* Another example of this is, *"It would be nice if we had more feedback from the platform about why people drop out, even though they are apparently interested in the subject. I don't have any answers to that. The platform does not really provide that type of feedback. You can see the statistics, you can see how many people have completed something or not but there is no way to say why."*

Advanced STEM MOOC Learners

Our team has analyzed learner usage in advanced STEM MOOCs offered through the edX platform. Through cluster analysis across courses, we have found five consistent learner usage patterns[3,4]: *Fully Engaged*, *Consistent Viewers*, *Two-Week Engaged*, *One-Week Engaged*, and *Sporadic Learners*. *Fully Engaged learners* access course materials and take the assessments throughout the duration of the course. *Consistent Viewers* also stay engaged with course materials through the course, but do not attempt many of the assessments. *Two-Week Engaged* learners fully participate in course materials, including assessments, but then disengage with the course. Like-wise, *One-Week Engaged* learners participate in all or most course materials for one week. The largest group, *Sporadic Learners*, access materials in no clear pattern.

We have administered and analyzed pre and post-surveys to learners enrolled in six advanced STEM MOOCs related to their level of preparation for the advanced content, interests, motivation to fully participate, and intentions to use the course materials. Post-surveys asked questions related to satisfaction with the course and feedback for improvement. To date, more than 4000 pre and post surveys have been collected. One interesting finding from survey respondents is that 58% of those who completed the course take the pre-survey, and 56% of those who stay engaged throughout the course completed the survey. Yet, 82% of those that sporadically use the materials did not complete the survey. This finding suggests that our survey results may generalize well for learners who fully engage and/or complete the course, while there is still little known about those that use the course more sporadically.[3]

Next Steps

Year 2 of the project will focus on testing what learner characteristics contribute to MOOC usage through predictive models, building a course analytics pipeline for visualizing learner performance, mapping of course characteristics, and development of evaluation tools (criteria and rubrics) useful for MOOC evaluation.

Bibliography

[1] Davidson, E. J. (2005). *Evaluation methodology basics: The nuts and bolts of sound evaluation*. Thousand Oaks, CA: Sage.

[2] Hicks, N., Zielinski, M., Wang, S. H., Douglas, K. A., Bermel, P., Diefes-Dux, H. A., & Madhavan. Intended Outcomes of Teaching a STEM MOOC. (Abstract submitted). *IEEE Frontiers in Education Conference*. Indianapolis, IN.

[3] Douglas, K. A., Mihalec-Adkins, B., Hicks, N., Diefes-Dux, H. A., Madhavan, K., & Bermel, P. (2016). Motivation and expectation learner trends in advanced nanotechnology-related MOOCs. *Proceedings of the American Society of Engineering Education,* New Orleans, LA.

[4] Douglas, K. A., Bermel, P., Alam, M. D., & Madhavan, K. (2016) Big data characterization of learner behaviour in a highly technical MOOC engineering course. *Journal of Learning Analytics, 3*(3), 170-192. http://dx.doi.org/10.18608/jla.2016.33.9