# Engaging Students for Success in Calculus with Online Learning Forums

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***Abstract*— It is said that we face an engineering "talent crisis" [1]; the United States is failing to keep pace in educating a highly skilled and diverse engineering workforce. Emphasis is currently placed on recruitment and retention of underrepresented minorities. Newer distance-delivered programs seek participation of non-traditional and geographically underrepresented students.**

**With expansion of educational offerings in engineering, one issue that emerges is student attrition during the first two years. It is suggested [2-4] that success in first year calculus reliably predicts persistence in engineering. To increase retention, new strategies are needed. Effective interventions may have the most impact if employed within the first year calculus sequence. Pedagogies that support traditional classroom learning as well as hybrid instruction and distance education offer the greatest transformative potential.**

**This work-in-progress paper describes research underway to evaluate the use of online learning forums during first year calculus. A freely available, wiki-based online learning forum is employed during a mixed-methods study. The study is conducted within sequential calculus courses distance-delivered across two academic years. Qualitative and quantitative data are used to evaluate the effect of forum use on student achievement, engagement and attitudes. A usage model is developed to disseminate within the STEM education community.**

***Keywords—distance education, engineering retention, social learning theory, mixed methods research***

## I. INTRODUCTION

A heightened focus on retention in engineering is evidenced in a number of research studies conducted to evaluate innovations in engineering mathematics instruction. These studies investigated the use of structured experiences [5], new curricula [6] and targeted interventions [7, 8] to improve retention. Other studies [2-4] have reported strong correlations between academic performance in first year calculus and attainment of an undergraduate engineering degree. A recent longitudinal study [2] indicated that success, measured solely by the grade achieved in *first semester* college mathematics and independent of secondary mathematics preparation or achievement, is itself a reliable predictor of retention among engineering undergraduates.

Recent data for the 2009-2011 academic years, gathered locally in conjunction with the Utah State University (USU) Advising Center, show that an average of 28% of USU engineering students enrolled in traditional (face-to-face) sections of Calculus I either withdrew from or failed the course (final course grade of W, D or F). This rate was nearly double - *an attrition rate of 52%* - during the same time frame for the engineering students enrolled in distance delivered (synchronous broadcast) sections of Calculus I.

Additional data, gathered in conjunction with the USU Office of Analysis, Assessment, and Accreditation from the same time period, indicate student satisfaction in the calculus sequence is lower for distance delivered than for traditional sections. During the 2009-2011 academic years, data from end of course student evaluations show that distance sections scored almost one full point lower (on a scale of 1-poor to 6-excellent) than traditional sections of Calculus I in ratings of instructor effectiveness (4.10 distance | 4.91 traditional) and overall quality of the course (3.96 distance | 4.90 traditional).

These data suggest that intervention strategies that target retention in calculus should not only focus on improving student academic achievement (knowledge and skills), but should also address affective outcomes such as student engagement and attitudes towards learning, the learning environment, available support, and the overall sense of learning community within the course. Researchers [9] have discussed that these are typical areas where students experience isolation, disconnectedness and dissatisfaction with the distance instruction. Thus, these are important areas to consider in designing interventions with a goal of improving retention.

## II. ONLINE LEARNING FORUMS AS INTERVENTION

### A. What are Online Learning Forums?

Online learning forums are discussion sites accessed via the internet by participants in a course. Online discussion sites allow individual learners to hold conversations with other individual learners, groups of learners, teaching assistants and instructors by posting text-based messages to the forum. Student access to a forum occurs asynchronously and apart from other synchronous learning sessions, meetings, or activities. Thus, despite their online nature, online learning forums are useful across the spectrum of educational delivery platforms (e.g. traditional, web-enhanced, online, etc.).

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### B. Theoretical Framework: Social Learning Theory

Social learning theory, as pioneered by Vygotsky, claims that learning is not simply "...an unfolding or maturation of pre-existing 'ideas'; on the contrary, it is the formation of such ideas-out of what originally was not an idea- in the course of socially meaningful activity" [10]. Online forums support important social influences on learning namely "competence" and "social" motivation to learn, "learner-friendly" formative assessment, and a community approach to learning [11].

*1) Motivation:* Student motivation is linked to learning achievement because the amount of time a student is willing to put into a subject is directly related to their motivation for learning the subject material. Competence motivation to learn decreases when learning "challenges" are either too easy or too difficult [11]. The goal of a learning forum is to provide enough timely feedback, whether from instructors, teaching assistants, or fellow students, so that students do not become frustrated and lose motivation for learning calculus and/or for pursuing engineering altogether.

Social motivation to learn increases when students perceive themselves to be helping others [11]. The online learning forum creates a virtual meeting place where students can meet online to share ideas and offer solutions that directly lead to learning. Thus, the benefits of the student as teacher paradigm can be realized even as students are geographically dispersed, studying alone during late night hours, or otherwise participating in distance education out of convenience. Moreover, use of the online forum can not only be adapted to differences in time and place between students and instructor, but also to differences in student learning styles and pace that are particularly prevalent among adult learners [12].

*2) Formative Assessment:* A system for continuous formative assessment is vital to promoting student learning and informing day-to-day instruction [11]. For pre-calculus high school seniors, researchers [13] found that frequent instructor interaction helped students to express and refine their level of mathematical understanding. The optimal occasion for formative assessment is during time of deep student engagement, usually during problem solving and homework preparation. Traditionally, instructor office hours have provided opportunity for this critical discourse to develop. With increasing numbers of non-traditional and working students and rising enrollment in distance education classes, physical attendance at instructor office hours is no longer feasible for many students. Thus, the availability of a 24/7 online forum that allows for more flexible instructor-student or student-student interaction could be transformative.

*3) Community Approach to Learning:* Learning is most effective *and* lasting when the environment is communal rather than punitive. In a true learning community, students are encouraged to attempt understanding, make mistakes, seek feedback, and revise their knowledge [11]. Creating a sociable learning community, however, can be difficult in classrooms when the subject matter is quantitative and presents "right" and "wrong" answers. Creating a true community for open discussion and problem solving may be easier to accomplish virtually, as students may sense some degree of anonymity and be more willing to ask questions or offer solutions online.

The growing popularity and common use of online social networking tools imply that students today may be more apt to converse in an online environments than in traditional classrooms. As evidence, researchers [14] have documented the growing use of "free, open, online, internet help forums" to learn mathematics. In these online mathematics forums, students voluntarily access help and communicate online anonymously with volunteers located throughout the world to get help on their homework and assignments.

## III. Research Project

### A. Description of the Research Project

*1) Pilot Study:* The researchers piloted Piazza in seven sophomore level engineering courses between Fall 2011 and Spring 2013. Six courses were small (5-14 students) and taught via synchronous video broadcast and one was large (>150 students) and taught traditionally (face-to-face). Students were surveyed to judge their use of and satisfaction with the forum. The results were overwhelmingly positive. Student responses in Fall 2011 and Spring 2012, 19/20 students reported that Piazza was at least somewhat effective in improving their learning and attitudes towards the course. Therefore, we hypothesize that use of the forum will improve both cogntive and affective student outcomes in calculus.

*2) Quasi-experimental Study:* In Fall 2013, we will implement the online learning forum as the treatment condition of a quasi experimental study conducted in distance delivered (via synchronous broadcast) sections of first year calculus across two academic years. Because random assignment of students is not feasible, a quasi-experimental nonequivalent control group design will be employed [15]. Assessment will measure the extent to which the online learning forum improves engineering student cognitive (academic achievement) outcomes as measured by quantitative data (student exam scores, post test results).

*3) Student Surveys, Observation and Interviews:* Student affective (engagement, attitudes, motivation) outcomes will be assessed and compared across both treatment and control groups of the quasi-experimental study using quantitative (end of course surveys) and qualitative (classroom observation, forum posts, artifact analysis, and targeted student interviews) data. Interviews will focus on students that fail or withdraw from the course. Quantitative and qualitative data will be used to develop a usage model to aid implementation of online learning forums througout the STEM education community.

*4) Research Questions:* Our research questions and associated assessment measures are:

1. How does student academic achievement vary with respect to participation in the forum? *(exam scores, artifact analysis)*
2. How does student interest in and attitudes toward learning calculus vary with respect to participation in the forum? *(survey, observation, interviews)*
3. How do students involve themselves in social interaction within the online forum? *(survey, observation, interviews)*
4. What motivations increase participation by high achieving vs. low achieving students? *(survey, observation, interviews)*
5. How can on-demand support be sustained over time? *(survey, observation, interviews)*

### B. Contribution of the Research Project

Researchers report a gap in the literature, particularly within undergraduate engineering education and the sciences, concerning "networked learning" [16], and the implementation of online forums [14]. The term "networked learning" is defined by the authors [16] as the use of information computer technology (e.g. asynchronous email and text messaging) to promote learning connections and directly fits the purpose and function of online learning forums described in this study. Therefore, there is potential for this project to break new ground in assessing the effects of online learning forums and in developing usage guidelines for dissemination throughout the STEM education community.

### C. Choice of Online Learning Forum

We choose to implement Piazza [17], a freely available, wiki-based online learning forum. Wikis are collaborative "groupware" that enable geographically dispersed, "virtual" teams to write "peer-produced" documents using a only text editor and a web browser [18]. The wiki nature of Piazza is one of its most unique and compelling educational features. Wiki based forums stand in contrast to traditional online forums using threaded discussions because wikis allow participants to edit for both organization and content [18]. It has been suggested [19] that threaded discussions are problematic for education because they exhibit incoherence and a lack of convergence that prevents learners from seeing the main ideas of the discussion or interchange. Since topics in threaded discussions are organized historically rather than conceptually, threaded discussions make it difficult for learners to place information into the correct context or conceptual framework, a skill that is needed for deep understanding. Additionally, Piazza's built-in equation editor and symbolic editing features make it an advantageous choice for STEM applications.

## IV. SUMMARY

Results of this mixed-methods study will be useful in formally assessing the effects of online learning forums on student cognitive and affective outcomes in STEM education settings. Quantitative and qualitative data will guide the development of a usage model to facilitate the use of online forums throughout the STEM community. Data gathered will provide deep insights into the role(s) that virtual learning communities and the social aspects of learning play in STEM education, pointing toward new avenues for investigation.

## REFERENCES


[1] R. Sevo, "The talent crisis in science and engineering," in *Apply Research to Practice (ARP) Resources*, B. Bogue and E. Cady, Eds., 2009.

[2] J. F. Gardner, P. A. Pyke, M. J. Belcheir, and C. B. Shrader, "Testing our assumptions: Mathematics preparation and its role in engineering student success," in *American Society for Engineering Annual Conference & Exposition*, Honolulu, HI, 2007.

[3] D. Budny, W. LeBold, and G. Bjedov, "Assessment of the impact of freshman engineering courses," *Journal of Engineering Education,* vol. 87, pp. 405-411, 1998.

[4] D. Koch and G. Herin, "Intervention strategy for improving success rates in calculus," in *American Society for Engineering Education Annual Conference & Exposition*, Chicago, IL, 2006.

[5] J. Hampikian, J. Gardenr, A. Moll, P. Pyke, and C. Schrader, "Integrated pre-freshman engineering and pre-calculus mathematics," in *2006 American Society for Engineering Education Annual Conference & Exposition*, Chicago, IL, 2006.

[6] R. Carr, D. H. Thomas, T. S. Venkataraman, A. L. Smith, M. A. Gealt, R. Quinn, and M. Tanyel, "Mathematical and scientific foundations for an integrative engineering curriculum," *Journal of Engineering Education,* vol. 84, pp. 137-150, 1995.

[7] S. E. Bamforth, C. L. Robinson, T. Croft, and A. Crawford, "Retention and progression of engineering students with diverse mathematical backgrounds," *Teaching Mathematics and its Applications,* vol. 26, pp. 156-165, 2007.

[8] J. Du Preez, T. Steyn, and R. Owen, "Mathematical preparedness for tertiary mathematics: A need for focused intervention in the first year?," *Perspectives in Education* vol. 26, pp. 49-62, 2008.

[9] S. Howell, P. Williams, and N. Lindsay, "Thirty-two trends affecting distance education: An informed foundation for strategic planning," *Online Journal of Distance Learning Administration,* vol. VI, 2003.

[10] A. Kozulin, *Vygotsky's psychology: A biography of ideas.* Cambridge, MA.: Harvard University Press, 1990.

[11] J. D. Bransford, A. L. Brown, and R. R. Cocking, Eds., *How people learn: Brain, mind, experience and school.* Washington, DC: National Academy Press, 2000.

[12] M. S. Knowles, E. F. Holton, and R. A. Swanson, *The adult learner: The definitive classic in adult education and human resource development*, 6th ed. Burlington, MA.: Elsevier., 2005.

[13] D. R. Illaria and C. A. Maher, "Growth in student mathematical understanding through precalculus student and teacher interactions," in *Annual Meeting for the North American Chapter of the International Group for the Psychology of Mathematics Education*, Snowbird, UT, 2001.

[14] C. van de Sande, "A description and characterization of student activity in an open, online, mathematics help forum," *Educational Studies in Mathematics* vol. 77, pp. 53-78, 2011.

[15] M. D. Gall, J. P. Gall, and W. R. Borg, *Educational research: An introduction*, 8th ed. Boston: Pearson Education, Inc., 2007.

[16] P. Goodyear, C. Jones, M. Asensio, V. Hodgson, and C. Steeples, "Networked learning in higher education: Students' expectations and experiences," *Higher Education,* vol. 50, pp. 473-508, 2005.

[17] (March 12). http://www.piazza.com.

[18] B. Leuf and W. Cunningham, *The wiki way: Quick collaboration on the web*. Boston, MA: Addison-Wesley Professional, 2001.

[19] A. Ioannou, "Online collaborative learning: The promise of wikis," *International Journal of Instructional Media,* vol. 38, pp. 213-223, 2011.