Mapping Entrepreneurial Minded Learning with the Longitudinal Model of Motivation and Identity in First-Year Engineering

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Work-in-Progress: Mapping Entrepreneurial Minded Learning with the Longitudinal Model of Motivation and Identity in First-Year Engineering Courses

Introduction

Engineering curriculum is evolving to incorporate more aspects of design and project-based learning as well as emphasizing the importance of creativity and entrepreneurship in engineering design [1]–[4]. The Ohio State University is collaborating with KEEN [5], a network of thousands of engineering faculty working to unleash undergraduate engineers so that they can create personal, economic, and societal value through the entrepreneurial mindset, to add multiple entrepreneurial minded learning (EML) elements to an existing first-year engineering course. This work-in-progress paper represents the first phase of a four-phase, 18-month pilot, during which we explored the impact of EML in first-year engineering classrooms on motivation and identity. While Phase 1 focuses primarily on engineering education research, phases 2, 3, and 4 target curriculum development, assessment, and dissemination, respectively.

This pilot will position us to expand our curriculum via the application of engineering education scholarship to support our students' development of EML. It will also demonstrate our ability to scale up EML-related curriculum in the first year of engineering while effectively training all members of the teaching team including faculty, graduate, and undergraduate teaching assistants.

Purpose

The purpose of the first phase of the pilot is to investigate the current practices of five of the thirty-five KEEN institutions that are currently incorporating EML elements into their first-year engineering curricula. Through assessing these current practices, we will be able to develop a curriculum that integrates the best practices and examines the progress of student motivation, identity, engineering skillsets, and learning over the first year. The overarching research question that we are studying is: *In what ways do entrepreneurial minded learning (EML) experiences affect first-year engineering students' motivation and identity development?* Additionally, we are seeking to answer the following sub-questions:
1. How do faculty incorporate EML into their first-year engineering courses?
2. How do students' experiences with EML evolve from the first- to fourth- year?

We approached this study through a convergent mixed methods design [6] because it best addressed our research question and allowed us to collect both qualitative and quantitative data simultaneously. The mixed methods study was designed so that mixing occurred in all phases: data collection, analysis, and discussion. This approach allowed us to obtain information using surveys, focus group interviews, and classroom observations, which provided deeper insights into students' motivation and identity in EML classrooms.

Background and Theoretical Framework

First-year engineering curricula use a variety of approaches, including common content across engineering disciplines (e.g., [7], [8]) and project-based design courses (e.g., [9]–[11]). Some of

these design projects incorporate entrepreneurship and other components of EML. For example, Brown University's Division of Engineering instituted a two-course sequence to merge entrepreneurship in an engineering design project, where students worked in teams to create a business plan and prototype for a product they created [12]. Additionally, the Franklin W. Olin College of Engineering sought to redesign their engineering curriculum to instill an "entrepreneurial thinking" culture in their program [13]. Our study assesses students' motivation and identity development in these types of entrepreneurship curricula.

For this study, we used the Longitudinal Model of Motivation and Identity (LMMI) [14] which combines self-determination theory (SDT) [15] with possible-selves theory (PST) [16]. The LMMI is a conceptual model that can be used to study individual development, incorporating the strengths of the well-established SDT and PST. In the framework, PST serves as the foundation for the SDT constructs of competence, autonomy, and relatedness. PST allows individuals to set goals, think to the future, and envision themselves after completing some experience while SDT allows for evaluation of the current context focusing on basic needs. The various SDT constructs lead to increased motivation and identity development while each experience, such as EML, is based on one's own identity and views of themselves in the future.

Methods

The institutions participating in the study are all members of the KEEN network and are currently incorporating EML elements into their first-year engineering curricula. They represent a variety of sizes of institutions as well as both public and private institutions. The student and faculty participants were recruited from these universities. We worked with our contacts at each of these universities to obtain IRB approval. The students and faculty were recruited using separate email protocols at each university. To increase our response rate, we sent up to two reminder emails to both the students and faculty at each university as needed and offered the students an incentive of a chance to win one of two $50 gift cards available for each university.

Four members of the team visited each of the institutions to collect data. Data collection consisted of focus groups with first-year engineering faculty who implement EML in the classroom, surveys of first- and fourth-year students to assess the short- and long-term impacts of EML as it relates to motivation and identity, and observations of EML classrooms to note current engagement in courses with EML practices.

We identified students for the study by sending the survey to all undergraduate students in their first or fourth year of study in the targeted programs at each institution and received about 50 responses per school. The 51-item survey was administered using Qualtrics, an online survey program, and took approximately 20 minutes to complete. The survey protocol assessed the KEEN Framework: the 3C's of the entrepreneurial mindset (curiosity, connections, and creating value), the engineering skillset elements (opportunity, design, and impact), and the educational outcomes (collaboration, communication, and character) [17]. These elements combined with the SDT basic needs scale [18] and Possible Selves questionnaire [19] to incorporate motivation and identity with EML.

We conducted semi-structured focus group interviews at each institution with first-year engineering faculty who implement EML in their classrooms. Approximately 8 questions were asked per focus group, which lasted an hour. Each focus group contained approximately two faculty members. Two researchers led the focus group: one facilitated the conversation while one took detailed notes. The focus groups were audio recorded in order to transcribe excerpts as needed to support the analysis of the detailed notes.

We observed one to two EML classrooms at each site to note current engagement in courses that implement EML practices. We assessed the frequency of EML skills used and how those skills were introduced (pedagogy). The observation protocol was a combination of the Global Real-time Assessment Tool for Teaching Enhancement (G-RATE), a valid and reliable tool framed around principles of the "How People Learn" conceptual framework, to assess the frequency of classroom activities [20]–[24], while observation notes will address pedagogies used related to EML. G-RATE observations produced instructor profiles that will be combined with other data to answer research questions. Additional artifacts were also collected, such as syllabi, handouts for the observed class, and presentations or other materials used in that class period. There were at least two researchers performing the observations, which included field notes and audio recordings of the faculty and students.

Analysis

We will map the findings from the information collected to the KEEN engineering mindset and skillsets along with the LMMI. Our analysis will use descriptive statistics and standard statistical methods such as ANOVA, t-tests, and clustering analysis, as appropriate, to analyze the survey data. We will use deductive coding of the focus group interviews followed by open coding to break down the items to better understand exactly what is contributing to student motivation and identity. Analysis of the observations data will include individual coding of transcribed audio recordings data by multiple researchers and group validation of individual coding to ensure validity and reliability of the data. We will triangulate the findings from the focus groups, observations, and student survey data to identify common trends as well as differences between schools and courses. As this is a mixed methods study, we will also employ mixing to find connections between all our data sets.

Current Work to Date and Next Steps

To date, we have completed all our data collection and plan to share initial findings and lessons learned related to the use of EML in first-year engineering programs at the conference. Specifically, we will continue our analysis and mapping of our LMMI findings to EML. Once mapping is complete, the results from Phase 1 will be used to develop a set of best practices that will be incorporated into EML projects, courses, and curriculum during Phase 2. Phase 3 will focus on examining the development of student motivation, identity, engineering skillsets, and learning throughout the newly developed curriculum. Phase 4 is the dissemination of our findings to KEEN network schools along with engineering and engineering education communities. A significant contribution of our project is the operationalization of LMMI in the context of EML which will inform future curriculum development, particularly for large first-year engineering design and project-based learning courses.

References

[1] A. J. Dutson, R. H. Todd, S. P. Magleby, and C. D. Sorensen, "A review of literature on teaching engineering design through project-oriented capstone courses," *J. Eng. Educ.*, vol. 86, no. 1, pp. 17–28, 1997.

[2] D. Clive *et al.*, "Engineering design thinking, teaching, and learning," *J. Eng. Educ.*, no. January, pp. 103–120, 2005.

[3] C. Charyton and J. A. Merrill, "Assessing general creativity and creative engineering design in first year engineering students," *J. Eng. Educ.*, vol. 98, no. 2, pp. 145–156, 2009.

[4] S. P. Nichols and N. E. Armstrong, "Engineering entrepreneurship: Does entrepreneurship have a role in engineering education?," *IEEE Antennas Propag. Mag.*, vol. 45, no. 1, pp. 134–138, 2003.

[5] The Kern Family Foundation, "KEEN: Engineering unleashed," 2017. [Online]. Available: https://engineeringunleashed.com/. [Accessed: 19-Feb-2018].

[6] J. W. Creswell and V. L. Plano Clark, *Designing and conducting mixed methods research*, 3rd ed. Thousand Oaks, CA: SAGE Publications, Inc., 2018.

[7] N. Al-Holou *et al.*, "First-year integrated curricula: Design alternatives and examples," *J. Eng. Educ.*, no. 98, pp. 435–448, 1999.

[8] N. a. Pendergrass *et al.*, "Improving first-year engineering education," *J. Eng. Educ.*, no. 99, pp. 10–14, 2001.

[9] K. A. Smith, S. D. Sheppard, D. W. Johnson, and R. T. Johnson, "Pedagogies of engagement: Classroom based practices," *J. Eng. Educ.*, vol. 94, no. 1, pp. 87–101, 2005.

[10] L. . Prendergast and E. . Etkina, "Review of a first-year engineering design course," in *121st ASEE Annual Conference & Exposition*, 2014.

[11] J. E. Mills and D. F. Treagust, "Engineering education - Is problem-based or project-based learning the answer?," *Australas. Assoc. Eng. Educ.*, vol. 3, no. 2, pp. 2–16, 2003.

[12] C. J. Creed, E. M. Suuberg, and G. P. Crawford, "Engineering entrepreneurship: An example of a paradigm shift in engineering education," *J. Eng. Educ.*, vol. 91, no. 2, pp. 185–195, 2002.

[13] S. Fredholm *et al.*, "Designing an engineering entrepreneurship curriculum for Olin College," *Proc. 2002 Am. Soc. Eng. Educ. Annu. Conf. Exhib. 1654*, vol. 0, no. JANUARY 2002, pp. 1–13, 2002.

[14] R. L. Kajfez, H. M. Matusovich, and W. C. Lee, "Designing developmental experiences for graduate teaching assistants using a holistic model for motivation and identity," *Int. J. Eng. Educ.*, vol. 32, no. 3, pp. 1208–1221, 2016.

[15] R. Ryan and E. Deci, "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being.," *Am. Psychol.*, vol. 55, no. 1, pp. 68–78, 2000.

[16] H. Markus and P. Nurius, "Possible selves," *Am. Psychol.*, vol. 41, no. 9, pp. 954–969, 1986.

[17] The Kern Family Foundation, "The KEEN Framework," 2017. [Online]. Available: https://engineeringunleashed.com/Mindset-Matters/Framework.aspx.

[18] selfdeterminationtheory.org, "Basic psychological need satisfaction scales & basic psychological need satisfaction & frustration scales," 2017. [Online]. Available: http://selfdeterminationtheory.org/basic-psychological-needs-scale/.

[19] D. Oyserman, D. Bybee, K. Terry, and T. Hart-Johnson, "Possible selves as roadmaps," *J. Res. Pers.*, vol. 38, no. 2, pp. 130–149, 2004.

[20] M. Cox, J. Hahn, N. McNeill, and A. Kulkarni, "Developing a global real-time assessment

tool for the teaching enhancement of engineering graduate teaching assistants," in *2010 American Society for Engineering Education Annual Conference and Exposition*, 2010.

[21] N. Sambamurthy, J. S. London, J. Hahn, J. Zhu, and M. F. Cox, "Reliability of the global real-time assessment tool for teaching enhancement (G-RATE)," in *2013 American Society for Engineering Education Annual Conference and Exposition*, 2013.

[22] A. H. Harris and M. F. Cox, "Developing an observation system to capture instructional differences in engineering classrooms," *J. Eng. Educ.*, vol. 92, no. 4, pp. 329–336, 2003.

[23] M. F. Cox and D. S. Cordray, "Assessing pedagogy in bioengineering classrooms: Quantifying elements of the 'How People Learn' model using the VaNTH Observation System (VOS)," *J. Eng. Educ.*, vol. 97, no. 4, pp. 413–431, 2008.

[24] J. D. Bransford, A. Brown, and R. Cocking, "How people learn: Mind, brain, experience, and school," *Washington, DC Natl. Res. Counc.*, 1999.