Exploring Pedagogical Risk-Taking of Engineering Faculty

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***Abstract*—This Research Work in Progress Paper presents a pilot study focused on understanding how faculty take pedagogical risks in 2nd and 3rd year (mezzanine level) engineering courses. Broadly, we are interested in understanding ways of making widespread changes in the mezzanine level of the curriculum. The purpose of this exploratory research is to develop an understanding of faculty pedagogical risk-taking through observations, interviews, and artifact analysis. The primary data for this project are observations of four mezzanine level engineering courses. During the observation we took detailed field notes and collected course handouts, lesson plans, or other course materials. After the lesson was completed, we conducted a post-observation teacher interview to learn about the broader context of that lesson within the class, how the lesson has evolved over time, and plans for that lesson in future courses. This work in progress serves as a pilot study to better understand how to capture pedagogical risk-taking in the classroom. Analysis of observations, field notes, and course material is being utilized to develop data collection techniques and investigation protocols for the future exploration of pedagogical risk-taking.**

Keywords—pedagogical risk-taking, innovation, pedagogy

I. INTRODUCTION

Higher education engineering instructors regularly make pedagogical choices in their classrooms. These choices are often accompanied by the autonomy of the instructor to choose an appropriate pedagogy based on perceived fit or a formal methodology [1]. Decisions regarding pedagogy selection are often informed by previous instructors as models, content knowledge, pedagogical content knowledge, and past experiences [2]. A variety of other factors, including individual characteristics, institutional culture, and local organization factors, influence how instructors plan and teach their courses [3]. These combined influencers on pedagogical choice commonly lead to norms that do not necessarily lead to teaching practices that maximize student learning, as they may encourage faculty to teach as they have been taught, thus not leading to changes in the ways that faculty teach. In this research, work in progress paper, we are interested in understanding faculty who are likely to make changes to their teaching practices, even though there is a risk of failure. In this paper, we refer to this phenomenon as pedagogical risk-taking.

Jamieson & Lohmann suggest that a culture for scholarly and systematic innovation is needed in engineering education for innovation and change to happen [4]. Our study set out to examine the degree to which such an innovative culture exists within an engineering program recognized by the National Academy of Engineering (NAE) as an exemplar for effectively incorporating real world experiences in the curriculum, the Bachelor of Science in Engineering (BSE) and the Bachelor of Science (BS) in Manufacturing Engineering programs in the Polytechnic School at Arizona State University [5]. In this study, situated in the larger National Science Foundation's (NSF) Revolutionizing Engineering Departments (RED) project, we specifically sought to observe and record faculty's pedagogical risk-taking. This effort was designed to inform the overarching goal of the RED project to empower faculty to be agents of change through the creation of a culture driven by pedagogical risk-taking and additive innovation.

In this work in progress paper, we will discuss our initial investigation of pedagogical risk-taking in engineering courses taught at the mezzanine (second and third year) level. We begin with a literature review providing greater detail into what is meant by pedagogical risk-taking. This background is followed by our approach taken for the pilot study and methodological implications that emerged when designing a study to observe instances of pedagogical risk-taking. These lessons learned form the foundation for the evolution of our investigation and our planned next steps.

II. LITERATURE REVIEW

Much attention has been given to the overwhelming need for fundamental change in STEM higher education instruction [6]. Many studies have been conducted identifying effective pedagogies and strategies for change, yet these efforts have resulted in only modest propagation of innovative classroom practices [7-14]. A key consideration in changing how STEM subjects are taught in higher education are the faculty who enact the change via classroom instruction. Change in the classroom can only occur if faculty are willing, able, and motivated to attempt to adopt alternative pedagogical approaches [4, 15-19].

The lack of adoption of effective pedagogies suggests that most faculty are unwilling, unable, or prefer to stick to what they know. Fear that the alternative will take too much time and effort or that the unknown will fail can be major hurdles for faculty [20-21]. Faculty being risk averse, i.e., defaulting to the status quo, negatively contributes to the already suspect engineering education culture that exists within most engineering programs [22-23]. This culture can be driven by

National Science Foundation Grant 1519339

many factors beyond individual faculty beliefs, including promotion and tenure processes, lack of experience, or job responsibility prioritization [24-25]. The support provided to faculty and the existing culture within which faculty reside has major influences on whether or not they are willing to take a pedagogical risk in their classrooms [26].

In our attempt to revolutionize our engineering program, we are attempting to create an innovative culture through encouraging a risk-taking mindset among the faculty. It is important to note that there is a distinction between innovation in the classroom and pedagogical risk taking. Pedagogical risk taking will likely lead to an innovative classroom. However, innovation in a classroom being present is not an indication that the faculty is engaging in pedagogical risk taking. In Kozma's grounded theory research exploring instructional innovation, he found that instructional innovation is primarily evolutionary [27]. In other words, instructional innovations are "broadened, extended, or mutated" from past practices [27, p. 307]. Ponticell found the psychology of risk-taking behavior to be a useful lens for understanding what she calls teacher risk taking [28]. Risk-taking behavior consists of the following: loss, significance of loss, and uncertainty [29]. In other words, pedagogical risk-taking involves trying new things in the classroom when there is a chance of failure, this failure is significant, and there is uncertainty around whether the new way of teaching will be accepted by students, peers, or administrators. In addition, Ponticell discusses the importance of a sense of gain when engaging in teacher risk taking [28]. These gains can be in the form of improving student learning, having more opportunities (such as leadership opportunities), or being provided with more time and resources to continue to develop teaching materials. This distinction is important in our current study as we are interested in increasing pedagogical risk-taking tendencies of our faculty, and this inherently involves trying something that has a potential to fail.

Others studying risk-taking in organizations have found that the support system plays a large role in the level of risk-taking that individuals are willing to attempt [26]. The possibility of failure is inherent any time a person truly engages in risk-taking and it is important for the person taking the risk to feel supported by their managers and leaders. Neves and Eisenberger found that perceived organizational support of risk-taking and a belief that risk-takers would not be punished, but rather accommodated in the event of failure, was a driving factor in building and sustaining a culture of risk-taking [26]. Perceived organizational support was positively related to failure-related trust, which was in turn related to a willingness to engage in risk-taking.

III. CONTEXT

This study takes place in a program that offers two undergraduate degrees: 1) BSE and 2) BS in Manufacturing Engineering. The curriculum is common for all students in the first two years of the program with students selecting their major and concentration (if pursuing the BSE) by the end of year two. The curriculum has a design spine throughout the four-year degree program with students taking three credit hour project courses each semester throughout the program. These project courses focus on design and applications of engineering content learned throughout the program. Many of these courses culminate in projects that are completed with partners in the community or with local industry. This program is relatively new, having admitted its first class of students in 2005. The program also merged with an engineering technology program in 2013. This merger has potential importance as many of the faculty from the engineering technology program are now teaching 2nd or 3rd year (mezzanine level) engineering science courses that are the focus of this study.

IV. PILOT STUDY

The broader project associated with this pilot study is interested in understanding how to make widespread change in the non-project courses in the mezzanine level of the curriculum. The purpose of this research is to develop an initial understanding of pedagogical risk-taking at the mezzanine level in non-project courses through observations, interviews, and artifact analysis. The following research question guides this study:

In what ways, if any, do faculty engage in pedagogical risk-taking in the mezzanine levels of an engineering curriculum?

In this work in progress paper, we will present our initial research design, lessons learned from the pilot study that attempted to answer this research question, and future research plans to answer the research question.

V. PARTICIPANT SELECTION

Syllabi were collected for 21 courses taught at the mezzanine level of the curriculum. A total of five courses included in the required project-spine were removed from this initial investigation because of the required project-based pedagogy. In addition the project-spine courses involve multiple sections, and there is an attempt to keep each section the same, thus there is less faculty autonomy in these courses. The remaining 16 syllabi were analyzed to select courses that appear to be implementing non-traditional instructional practices. Syllabi assessment defined non-traditional instructional practices as pedagogical practices that included projects, hands-on activities, or descriptions of activities outside of a traditional engineering course using classroom lecture, quizzes, and/or exams. We rated each syllabus as being low, medium, or high in the implementation of non-traditional teaching methods. Those categorized at the low level displayed no evidence of non-traditional instructional practices in the syllabus (ten courses). Courses classified as low appeared to use traditional methods including lectures and a schedule of quizzes and exams. Those categorized at the medium level had projects or some evidence of non-traditional instructional practices in the syllabus (four non-project courses). Those categorized at the high level had significant evidence of non-traditional instructional practices, such as interactive teaming exercises and real-world engineering problem-solving scenarios (two courses). This initial artifact analysis was used to select courses to observe for this work-in-progress study.

We emailed the instructors for classes categorized as medium or high (seven total) to request that two researchers attend and observe a class session; five instructors volunteered to participate. Of these, four were in person courses and one was online. For this study, we focused on the in-person courses. Instructors were also asked to participate in a post-observation interview to help the researchers understand how the specific lesson fit into the larger class, what the objectives were for the lesson, and the history of the lesson.

VI. DATA COLLECTION

The primary data for this project are observations that were conducted in four mezzanine level engineering courses. Classroom observations have been used and can be helpful in identifying students' responses, instructor interactions, and to learn and disseminate best practices [30-31]. During the observation, we took detailed field notes. Immediately after the observation, we conducted a post-observation teacher interview to ask the faculty member questions around how the faculty first came up with the idea for the lesson, their assessment of how the lesson went, their plans to use or modify that lesson in future iterations of that course or in other courses, and other stories of trying new lessons or projects in the classroom. In addition, we collected course handouts, lesson plans, and any other course materials to supplement our observations. Finally, each researcher wrote an analytic memo describing the observation [32. This memo helped us create a more cohesive account of the observation to be used in analysis. Analytic memos focused on the research design were also written to help us realize any insights gained during the process of this pilot project that pertained to the research design. These analytic memos were early drafts of the implications that are presented later in this paper.

VII. DATA ANALYSIS

We initially planned to conduct structural coding, where we would generate a set of codes that related to pedagogical risk-taking [33]. However, we realized after the observations and through the writing of our analytic memos that we had not observed pedagogical risk-taking, which was central to answering the research question guiding this study. At this point, a decision was made to change our plans for data analysis to focus on the analytic memos and field notes. Our evolved purpose shifted toward developing a deeper understanding of the methodological implications of this pilot study on future research. The analytic memos were reviewed to identify these methodological implications. An illustrative example for each lesson learned was identified from the observation field notes or analytic memos. The following section shares these lessons learned with accompanying illustrative examples and methodological implications.

VIII. LESSONS LEARNED AND METHODOLOGICAL IMPLICATIONS

This paper focuses on lessons learned from the pilot study regarding ways of improving the future, large scale research effort. The following sub-sections will focus on a lesson learned in the pilot study, an illustrative example from the data that exemplifies this lesson learned, and methodological implications that arise from each lesson.

A. Innovations vs. Pedagogical Risk-Taking

During the observations and subsequent data analysis, we began to see a significant difference between innovation and pedagogical risk-taking. Many of the courses that were observed were innovative in their use of pedagogical techniques that did not follow a traditional lecture format. This innovation was not observed to be accompanied by pedagogical risk-taking of the instructor.

Illustrative example: An example of this was an observation of a course that was rated as 'high' in the syllabus analysis portion of this study. This class is a required, mezzanine level course. During the day that we observed the class, the class was working in teams or individually on mini-projects where they were required to collect data. Students had prepared for this class by creating a trebuchet, airplane, or robot from a kit provided by the instructor. The students were very engaged in the class as they began collecting data. The two observers in the class noted that there may be some aspects of pedagogical risk-taking occurring, but during the post-observation interview, we learned that the instructor has taught this class four times and that each of these times, this project has been employed. There have been some iterations to the project, but there were never large changes. This suggests that the instructor is not demonstrating pedagogical risk-taking. The initial inception of this activity was innovative and pedagogically risky, but it is no longer risky due to its continuous implementation without changes that may upset the proven pedagogical successes.

Methodological implication: The primary methodological implication that we took away from this theme and the illustrative example is that we need to find a more effective way of selecting participants for this study. One possible way to do this is to deploy a pedagogical risk-taking survey to teachers in our program, and to use the results of this survey to select participants. Fortunately, our broader RED team is in the final stages of creating a quantitative survey that measures pedagogical risk-taking. Another possibility for participant selection is to analyze faculty reflections, which include what worked well in their class and plans for improvements in future semesters, that are produced as part of our accreditation process.

B. Project-based does not necessarily equate to innovative

We limited our participating faculty to those teaching in the mezzanine and faculty teaching non-project courses. We now recognize that many elective courses at the mezzanine level are very project-focused. Two courses that are project-focused were observed in this pilot study because they were identified as medium or high during the syllabus review.

Illustrative example: One of the courses that we observed was an undergraduate elective machining lab course. This course is intended to be taken during the first or second year of study, but, many students take it during their last year. We noticed pretty quickly during our observation that this course was a traditional machining course. The way of teaching is similar to what would be expected; two instructors each taking half of the class, doing a demonstration of the machining steps that are to take place during that day, and then the instructors walking around and helping students or providing guidance as needed. We learned during the post-observation interview that this course has been taught the same way for 20 years. There was one change made when a second lab manager was hired, which allowed the course to be split into two cohorts or 24 total students.

Methodological implication: The primary methodological implication that was taken away from this example was that, again, our participant selection needs to be revised, and that we may need to scope the focus of our study. This course may be considered by some to be innovative because it involves a project-based curricula. However, many would view this class as a very traditional course that would have been present in many engineering technology programs. Again, we need to determine a better way to identify faculty who are engaging in pedagogical risk-taking.

C. Lack of Pedagogical Risk-Taking Observed

We discovered during our pilot observations that we were unable to answer our research question because we have yet to see any instances of pedagogical risk-taking. We have already suggested that our participant selection was flawed and did not point us to possible instances of pedagogical risk-taking. Another possibility is that there is little pedagogical risk-taking currently taking place in the mezzanine level our engineering curriculum.

Illustrative example: The course that we observed that was the closest to embracing pedagogical risk-taking in the classroom was a course that is associated with an extracurricular project. Students enrolled in this class work on different aspects of the project in preparation for a yearly competition. The project changes each year based on the competition requirements. These changes in constraints and project objectives lead to changes in the course but have not translated in changes made to the way the course is taught.

Methodological implication: We began this project with a belief or bias that pedagogical risk-taking was taking place in our program. We have faculty who value undergraduate education and our larger college and university embrace making changes and challenging the status quo, as demonstrated in our vision and mission statements and in many of our policies. We believed that we would find instances of pedagogical risk-taking in the mezzanine level of our program, but recognize now that we need to determine what to do if, as we continue this study, we do not find pedagogical risk-taking within the mezzanine level of our curriculum.

IX. FUTURE WORK

This pilot study has helped us define our future goals more explicitly. Our purpose moving forward is two-fold. First, we are interested in conducting a larger research study to better understand pedagogical risk-taking by engineering faculty in the mezzanine level of the curriculum. We will likely need to expand our research participants to include faculty from our broader college of engineering to provide a larger pool of faculty candidates. We will begin identifying participants using the pedagogical risk-taking instrument that our broader team is currently finalizing. This will help us identify engineering faculty who are likely to take pedagogical risks. We can then identify faculty teaching in the mezzanine level and request to have them as participants in our study. If this approach is still unsuccessful, we will go broader and identify engineering faculty from other institutions based on their responses to this instrument and request an in-person or virtual observation and interview.

Second, we plan to develop an intervention to encourage more pedagogical risk-taking in our faculty and begin to develop a culture of pedagogical risk-taking within our unit. This plan will include the creation of a program where faculty will meet for workshops at the beginning and end of the semester. Faculty will develop a test card (borrowed from the Business Model Canvas toolset for entrepreneurial ventures) during the first workshop where they will propose something that they will plan to implement in their course in the coming semester [34]. The test cards will propose a new pedagogy to use in the classroom and develop a way to quickly evaluate the implementation of that idea for future iterations. We will help them develop a way to quickly evaluate this implementation and learn from the implementation. We will observe the class on the day or days that they plan to implement their test card idea. All participants will present a poster during the workshop at the end of the semester, which describes their innovation, how the implementation went, and what they learned from the evaluation to implement in the future. Participation in this program will be incentivized with grant funds that can be used to purchase materials for the classroom or, for example, provide some summer funding to support faculty time needed to develop ideas more fully.

X. CONCLUSION

This research work-in-progress paper presents a study focused on understanding how faculty take pedagogical risks in mezzanine level engineering courses. The preliminary results suggest that some innovation is occurring, but that pedagogical risk-taking is for the most part absent. Incremental changes have been observed in engineering classrooms and curricula, but much of this is occurring in the first and final years of the curricula. Little innovation has occurred in the mezzanine level of the curriculum and we expect that increasing pedagogical risk-taking of faculty will result in changes and innovation in engineering courses. Greater strides are needed, first, to understand pedagogical risk taking so that we can eventually attain a culture of pedagogical risk-taking among program faculty.

ACKNOWLEDGEMENT

This work is supported by the National Science Foundation Grant 1519339. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. In addition, we would like to thank the instructors who allowed us to observe their classes, the other members of the Arizona State University RED team for their support, and the FIE reviewers for their valuable feedback.

REFERENCES

[1] A. Oleson and M. T. Hora, "Teaching the way they were taught? Revisiting the sources of teaching knowledge and the role of prior experience in shaping faculty teaching practices," Higher Education, vol. 68, no. 1, pp. 29–45, 2013.

[2] N. Hativa and P. Goodyear, "Research on teacher thinking, beliefs, and knowledge in higher education: Foundations, status and prospects," Teacher Thinking, Beliefs and Knowledge in Higher Education, pp. 335–359, 2002.

[3] J. S. Stark, "Planning introductory college courses," Teacher Thinking, Beliefs and Knowledge in Higher Education, pp. 127–150, 2002.

[4] L. Jamieson and J. Lohmann, "Innovation with impact: Creating a culture for scholarly and systematic innovation in engineering education," Washington, DC: American Society for Engineering Education, 2012.

[5] National Academy of Engineering, "Infusing real world experiences into engineering education," 2012.

[6] M. Besterfield-Sacre, M. F. Cox, M. Borrego, K. Beddoes, and J. Zhu, "Changing engineering education: Views of U.S. faculty, chairs, and deans," *Journal of Engineering Education*, vol. 103, no. 2, pp. 193–219, 2014.

[7] M. Borrego, J. E. Froyd, and T. S. Hall, "Diffusion of engineering education innovations: A survey of awareness and adoption rates in U.S. engineering departments," *Journal of Engineering Education*, vol. 99, no. 3, pp. 185–207, 2010.

[8] National Research Council, "Discipline-based education research," 2012.

[9] K. A. Smith, S. D. Sheppard, D. W. Johnson, and R. T. Johnson, "Pedagogies of Engagement: Classroom-Based Practices," *Journal of Engineering Education*, vol. 94, no. 1, pp. 87–101, 2005.

[10] C. Henderson, A. Beach, and N. Finkelstein, "Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature," *Journal of Research in Science Teaching*, vol. 48, no. 8, pp. 952–984, Feb. 2011.

[11] M. Borrego and C. Henderson, "Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies," *Journal of Engineering Education*, vol. 103, no. 2, pp. 220–252, 2014.

[12] A. F. Mckenna, J. Froyd, and T. Litzinger, "The Complexities of transforming engineering higher education: Preparing for next steps," *Journal of Engineering Education*, vol. 103, no. 2, pp. 188–192, 2014.

[13] A. Kezar and P. D. Eckel, "The effect of institutional culture on change strategies in higher education," *The Journal of Higher Education*, vol. 73, no. 4, pp. 435–460, 2002.

[14] E. Seymour, "Tracking the process of change in US undergraduate education in science, mathematics, engineering, and technology," *Science Education*, vol. 86, pp. 79–105, 2001.

[15] C. L. Colbeck, A. F. Cabrera, and R. J. Marine, " Faculty motivation to use alternative teaching methods," Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA, USA, April 1, 2002.

[16] C. J. Finelli, K. M. Richardson, and S. R. Daly, "Factors that influence faculty motivation of effective teaching practices in engineering, in Proceedings of the American Society for Engineering Education Annual Conference & Exposition, Atlanta, GA, USA, June 23-26, 2013.

[17] H. M. Matusovich, M. C. Paretti, L. D. McNair, and C. Hixson, "Faculty motivation: A gateway to transforming engineering education," Journal of Engineering Education, vol. 103, no. 2, pp. 302-330, 2014.

[18] E. M. Rogers, "Diffusions of innovation," New York City: Simon and Schuster, 2003.

[19] J. F. Wergin, "Beyond carrots and sticks: What really motivates faculty," Liberal education, vol. 87, no. 1, pp. 50-53, 2001.

[20] S. E. Brownell and K. D. Tanner, "Barriers to faculty pedagogical change: Lack of training, time, incentives, and...tensions with professional identity?," *Cell Biology Education*, vol. 11, no. 4, pp. 339–346, Jan. 2012.

[21] J. Tagg, "Why does the faculty resist change?," *Change: The Magazine of Higher Learning*, vol. 44, no. 1, pp. 6–15, Apr. 2012.

[22] A. Carberry and D. Baker, "Cultural impacts on engineering," In J. Dori, Z. Mevareach, and D. Baker (Eds.), Cognition, metacognition and culture in STEM education (pp. 217-240). Springer, New York, NY, 2017.

[23] E. Godfrey and L. Parker, "Mapping the cultural landscape in engineering education," *Journal of Engineering Education*, vol. 99, no. 1, pp. 5–22, 2010.

[24] E. Godfrey, "Understanding disciplinary cultures: The first step to cultural change," In A. Johri & B.M. Olds (eds.), Cambridge handbook of engineering education research. New York: Cambridge University Press, 2014.

[25] A. N. Link, C. A. Swann, and B. Bozeman, "A time allocation study of university faculty," *Economics of Education Review*, vol. 27, no. 4, pp. 363–374, 2008.

[26] P. Neves and R. Eisenberger, "Perceived organizational support and risk-taking," *Journal of Managerial Psychology*, vol. 29, no. 2, pp. 187–205, Apr. 2014.

[27] R. B. Kozma, "A Grounded Theory of Instructional Innovation in Higher Education," *Journal of Higher Education*, vol. 56, no. 3, pp. 300–319, 1985.

[28] J. A. Ponticell, "Enhancers and Inhibitors of Teacher Risk Taking: A Case Study," *Peabody J. Educ.*, vol. 78, no. 3, pp. 5–24, 2003.

[29] J. F. Yates and E. R. Stone, "The risk construct," in *Risk-taking behavior*, Chichester, England: Wiley, 1992, pp. 1–25.

[30] D. Sawada, M. D. Piburn, E. Judson, J. Turley, K. Falconer, R. Benford, and I. Bloom, "Measuring reform practices in science and mathematics classrooms: The reformed teaching observation protocol," *School Science and Mathematics*, vol. 102, no. 6, pp. 245–253, 2002.

[31] P. Shekhar, M. Demonbrun, M. Borrego, C. Finelli, M. Prince, C. Henderson, and C. Waters. "Development of an observation protocol to study undergraduate engineering student resistance to active learning," *International Journal of Engineering Education*, vol 31, no 2, pp 597-609, 2015.

[32] J. Saldaña, *The coding manual for qualitative researchers*. Los Angeles: Sage Publications, 2016.

[33] J. Saldaña, *The coding manual for qualitative researchers*. London: SAGE, 2016.

[34] A. Osterwalder, Y. Pigneur, G. Bernarda, and A. Smith, *Value proposition design: how to create products and services customers want.* oboken: John Wiley & Sons, 2014.