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Measuring the Effects of Pre-College Engineering Experiences, Year 2

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Noah Salzman is an Assistant Professor at Boise State University, where he is a member of the Electrical and Computer Engineering Department and IDoTeach, a pre-service STEM teacher preparation program. His work focuses on the transition from pre-college to university engineering programs, how exposure to engineering prior to matriculation affects the experiences of engineering students, and engineering in the K-12 classroom. He has worked as a high school science, mathematics, and engineering and technology teacher, as well as several years of electrical and mechanical engineering design experience as a practicing engineer. He received his Bachelor of Science degree in Engineering from Swarthmore College, a Masters of Education degree from the University of Massachusetts, and a Masters of Science in Mechanical Engineering and Doctorate in Engineering Education from Purdue University.

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Matthew W. Ohland is Professor of Engineering Education at Purdue University. He has degrees from Swarthmore College, Rensselaer Polytechnic Institute, and the University of Florida. His research on the longitudinal study of engineering students, team assignment, peer evaluation, and active and collaborative teaching methods has been supported by over $14.5 million from the National Science Foundation and the Sloan Foundation and his team received Best Paper awards from the Journal of Engineering Education in 2008 and 2011 and from the IEEE Transactions on Education in 2011. Dr. Ohland is Chair of the IEEE Curriculum and Pedagogy Committee and an ABET Program Evaluator for ASEE. He was the 2002–2006 President of Tau Beta Pi and is a Fellow of the ASEE and IEEE.

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Measuring the Effects of Pre-College Engineering Experiences

Abstract

The implementation of co-curricular and extracurricular pre-college engineering programs has expanded dramatically in recent years. Many states now include engineering as part of their education standards for both students and teachers, reflecting the increasing acceptance of engineering at the K-12 level and its potential value to students. In addition to promoting outcomes that benefit all students regardless of career aspirations such as increased math and science achievement and greater technological literacy, K-12 engineering programs have been identified as a means of recruiting and retaining potential students in engineering.

The growth of pre-college engineering programs means that increasing numbers of incoming engineering students will have had some exposure to engineering prior to their enrollment in engineering programs. However, the effects of pre-college engineering experiences on undergraduate engineering students are relatively unexplored. To address this lack of understanding, this study uses a mixed-methods exploratory approach to examine how exposure to pre-college engineering programs affects the experiences of university engineering students. Conducting and analyzing phenomenographic interviews with cohorts of first year engineering students yielded five qualitatively different ways undergraduate engineering students experience the transition from pre-college to university engineering. These experiences range from feeling trapped in engineering due to pre-college engineering, to feelings of boredom and frustration due to misalignments between the two sets of experiences, to experiencing a boost in confidence and the ability to help others as a result of participation in pre-college engineering programs.

We are currently utilizing these qualitative results to develop an instrument to measure the extent of these effects in the larger population of undergraduate engineering students at multiple institutions. We are also exploring the relationship between pre-college engineering participation and quantitative measures of success in undergraduate engineering, including grades and persistence.

While some undergraduate engineering programs may take into account pre-college engineering experiences when forming design teams, most undergraduate programs assume little to no formal exposure to engineering prior to matriculation. The results of this research will help engineering administrators, instructors and designers of undergraduate and pre-college curricula adapt to students' changing needs and abilities as a result of their increased experience with engineering prior to university.

Summary of Work Completed Over the Past Year

Major work completed over the past year included the phenomenographic analysis of interviews with twenty-three first-year engineering students and development of an outcome space consisting of five categories of description of students' ways of experiencing their transition from pre-college engineering programs and activities to a first-year engineering classroom. These results, described in the following section, provide a theoretical framework that is

currently guiding the development of a quantitative instrument to understand students' transitions to first-year engineering on a larger scale across multiple institutions.

Qualitative Results

Figure 1 shows the outcome space illustrating the relationships between the five ways of experiencing the transition from pre-college to first-year engineering. In order of increasing integration in first-year engineering, that categories are Foreclosure, Frustration, Tedium, Connection, and Engaging Others.

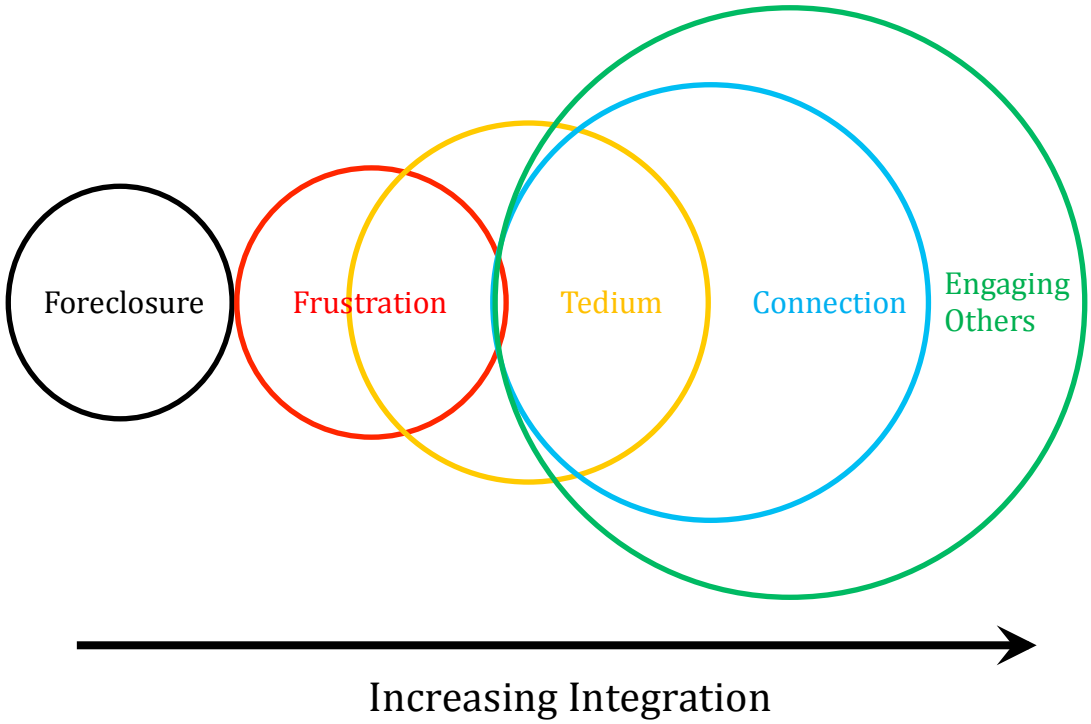

Figure 1: Phenomenographic outcome space of ways of experiencing the transition from pre-college to first-year engineering.

The first way of experiencing the transition to first-year engineering, Foreclosure, can be described as follows: The transition to college engineering is experienced as inevitable based on participation in pre-college engineering programs and characterized by a feeling of entrapment. Engineering is useful and a pathway to a stable career, but not a source of passion or true fulfillment.

The second category of description of ways of experiencing the transition is Frustration. This frustration stems from multiple sources, including unmet expectations of the First-Year Engineering experience, issues with the relevance and authenticity of what is being learned in the engineering classroom, academic struggles, and less of a sense of belonging. Participants whose experiences characterize this category display a strong commitment to engineering, but struggle with finding this connection in the First-Year Engineering program. While the experience of the transition from pre-college to First-Year Engineering is characterized by the frustration, reactions

to this frustration include both drawing from pre-college engineering as a source of motivation to persist or leaving engineering to study engineering technology in hopes of eliminating the sources of frustration in First-Year Engineering.

The third way of experiencing the transition to college engineering is Tedium. The tedium is due to having significant prior exposure to engineering projects perceived as more authentic, perceiving First-Year Engineering as less academically intense than pre-college engineering, and repeating content already learned in pre-college engineering. Although the experiences that make up this category can be characterized as demonstrating a high degree of confidence and ability to do engineering, this leads to disengagement in First-Year Engineering as opposed to promoting success in first-year engineering. This disengagement leads to seeking other opportunities to do engineering design perceived as more authentic or useful.

Connection, the fourth category of description, reflects a smooth transition from pre-college to First-Year Engineering characterized by the recognition of strong connections between the two contexts and a firm sense of belonging in engineering. Pre-college engineering experiences foster this sense of belonging by facilitating the exploration of engineering and deciding if it is an academic and career pathway worthy of further pursuit. Prior mastery of engineering content facilitates learning similar content in First-Year Engineering, further contributing to experiencing the transition as a series of connections and easing the transition from pre-college to college engineering. Exposure to pre-college engineering content that is not included in First-Year Engineering helps foster a bigger picture understanding of engineering, and conversely, this bigger picture understanding can promote the recognition of the utility of First-Year Engineering content. Ultimately, the increased awareness of engineering and sense of belonging in First-Year engineering provides an increased drive and motivation in comparison to the experiences of peers' experiences of the transition from pre-college to university engineering.

Sharing the confidence, belonging in engineering, and ability to be successful as the previous category of description, the experiences that define the category Engaging Others all involve the ability to work well with others. This ability primarily manifests in engineering design teaming experiences as a willingness to listen to others, patience with other teammates' ideas and an ability to incorporate ideas from group members in the design product, and recognition of the value of multiple perspectives in the engineering design process.

Development of Quantitative Instrument

We are currently utilizing the previously described results of the qualitative analysis to develop a survey instrument to allow for the collection of quantitative data from a larger sample of students across multiple institutions. This involves creating Likert-style survey items based on the qualitative data, as well as identifying items from existing instruments that align with the experiences described in the qualitative data. The instrument will be initially validated by expert review, followed by further validation with a small sample of students before being administered to a larger sample of students to generate a sample for factor analysis. We will then administer the final instrument to a large sample of students across multiple institutions.

Publications to Date

- Salzman, N. (2014, August). *A Phenomenographic Study Of Students' Experiences With Transition From Pre-College Engineering Programs To First-Year Engineering* (Doctoral dissertation). Purdue University, West Lafayette, IN.
- Salzman, N., & Ohland, M. W. (2013). Precollege Engineering Participation among First-Year Engineering Students. In *Proceedings of the 5th First Year Engineering Experience (FYEE) Conference*. Pittsburg, PA.
- Salzman, N., Ohland, M. W., & Cardella, M. E. (2014a). Measuring the Effects of Precollege Engineering Education. Presented at the American Society for Engineering Education Annual Conference, Indianapolis, IN.
- Salzman, N., Ohland, M. W., & Cardella, M. E. (2014b). Work In Progress-A Qualitative Study of the Effects of Participation in Pre-College Engineering Programs on First-Year Engineering Students. Presented at the 2014 IEEE Frontiers in Education Conference, Madrid.
- Salzman, N., Ricco, G. D., & Ohland, M. W. (2014). Pre-College Engineering Participation Among First-Year Engineering Students. Presented at the American Society for Engineering Education Annual Conference, Indianapolis, IN.

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