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Building Alignment Between Pre-college and First-Year Engineering Programs

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Building Alignment Between Pre-college and First-Year Engineering Programs

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Abstract - **Developments in pre-college engineering such as the incorporation of engineering in the Next Generation Science Standards and the rapid growth of formal and informal pre-college engineering programs and activities has resulted in increasing numbers of students arriving in first-year engineering programs with significant prior engineering experience. To assist first-year engineering faculty and staff with improving the alignment of their programs with their students' pre-college engineering experiences, in the first part of this workshop we present a framework we developed to understand how pre-college engineering programs and activities influence students' transitions into first-year engineering programs. Supported by both qualitative and quantitative data, we will describe ways that pre-college engineering activities can both support and hinder this transition. For the second part of this workshop, we will work with the participants to identify and share ways that they recognize elements of this framework in their own first-year engineering programs, brainstorm and share strategies for promoting successful transitions from pre-college to first-year engineering, and ways to differentiate instruction to address the wide range of pre-college engineering experiences represented in the first-year engineering classroom. This workshop presents a means for participants to begin a larger conversation related to understanding the impact of pre-college engineering participation on the first-year engineering experience, and ways that first-year engineering programs can adapt to address the changing conceptions of and experience with engineering of incoming students.**

Index Terms – Pre-college engineering, college transition, first year engineering alignment

PURPOSE OF THE WORKSHOP

The recent growth of pre-college engineering (PCE) programs and activities means that increasing numbers of students are matriculating into first-year engineering (FYE) programs with significant prior exposure to engineering. The goal of this workshop is to help FYE instructors and course designers better address the needs of these students by helping them to understand the nature and extent of PCE. Workshop participants will learn how PCE influences students' transitions to FYE utilizing a theoretical framework we developed to understand this experience. This will help frame group discussions on how the first-year engineering education community currently addresses students' PCE experiences, and provide the opportunity to engage in constructive dialogue focused on how FYE instructors can facilitate the transition from PCE to FYE. Table 1 provides an overview of the workshop.

TABLE I
WORKSHOP OVERVIEW

Topic	Description
Introduction	Introductions and workshop objectives
An Overview of Pre-College Engineering	Brief description of the history, types, and extent of pre-college engineering experiences
Measuring the Effects of Pre-College Engineering	Introduction of a theoretical framework and presentation of results of a study exploring students' transitions from pre-college to first-year engineering
Interactive Discussion	Share current practices addressing pre-college engineering experiences in FYE and explore ways to better align these domains

OVERVIEW OF PRE-COLLEGE ENGINEERING

Pre-college engineering programs and activities occur in many forms and contexts. Many K-12 students encounter engineering through the integration of engineering activities in elementary, middle, or high school mathematics and science instruction, while stand-alone semester and year-long engineering courses such as those developed by Project Lead The Way [1] and the International Technology and Engineering Education Association (ITEEA) [2] are also increasingly offered in middle and high schools. Extracurricular engineering opportunities exist as well, such as robotics competitions like those sponsored by FIRST Robotics [3] and engineering clubs. Many colleges of engineering offer numerous outreach programs and events to promote young peoples' interest in engineering, while informal learning spaces such as science museums also include hands-on engineering design activities.

Growth in the incorporation of engineering in science classrooms has been promoted by the inclusion of engineering practices and content in the Next Generation Science Standards [4]. These standards are utilized by many states to develop their own standards, and the inclusion of engineering provides strong motivation to incorporate this content in state science education standards. Recent analyses of state education standards have shown the widespread inclusion of engineering knowledge and

practices, providing further evidence of the growth of pre-college engineering [5], [6].

Measuring the Effects of Pre-College Engineering

The growth in pre-college engineering programs and activities means that increasing numbers of first-year engineering students have significant experience with engineering prior to their enrollment in first-year engineering courses. To understand the impact of pre-college engineering programs and activities we designed an exploratory mixed-methods study to explore how these experiences influence students' transitions into first-year engineering programs.

This study involved conducting and analyzing phenomenographic interviews with first-year engineering students with a variety of pre-college experiences to explore how their pre-college participation influenced their transition into first-year engineering [7], [8]. This resulted in the development of the outcome space consisting of five categories of description shown in Figure 1.

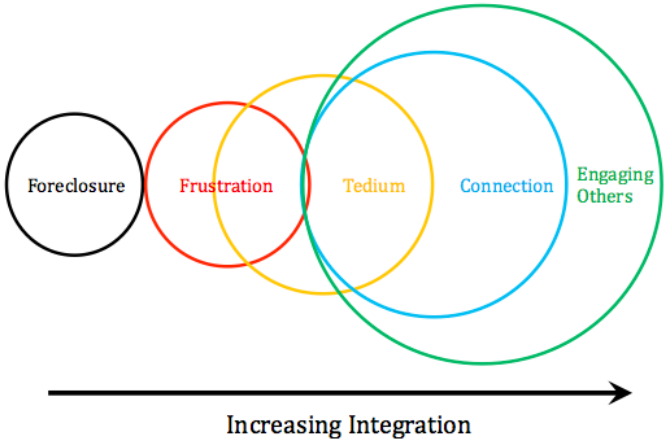

FIGURE 1
OUTCOME SPACE REPRESENTING WAYS OF EXPERIENCING THE TRANSITION FROM PRE-COLLEGE TO FIRST-YEAR ENGINEERING

In order of increasing integration in first-year engineering, students experience the transition as Foreclosure, Frustration, Tedium, Connection, and Engaging Others. Foreclosure captures the experiences of students who feel trapped in engineering, and are enrolled in first-year engineering due to external pressures or not being open to pursuing a different degree despite not being satisfied with engineering. Students experience Frustration due to misalignment between PCE and FYE, being underprepared for the mathematics and science involved in studying engineering, and finding FYE projects and peers less engaging that what they experienced in PCE. Tedium also involves frustration, but with the added element of feeling like FYE is less challenging than PCE. In contrast, the students whose experiences informed the development the Connection category felt better prepared and more confident in their ability to be successful in FYE due to their PCE experiences. Finally, experiencing the transition as Engaging Others involved utilizing PCE experiences to help others be successful in FYE.

In addition to presenting the qualitative results of this study, we will also briefly summarize the quantitative data collected as well. This will include a brief summary of the development and administration of a quantitative instrument [9] built around the framework described in the previous section, as well as summarizing the PCE activities reported by FYE engineering students in two different programs [10]–[12].

Interactive Discussion of the Transition from Pre-College to First-Year Engineering

The majority of time in this workshop will be dedicated to participants discussing their current practices addressing students' PCE experiences in FYE, and addressing ways to strengthen the alignment and build stronger connections between PCE and FYE. We will facilitate the discussions using the Think-Pair-Share [13] active learning technique, where we will encourage participants to reflect on a particular topic, share with a neighbor or in small groups at tables, and end with the opportunity to share small group discussions with the entire group.

The first half of the interactive discussion will focus on participants sharing current ways that they address students' PCE experiences in their FYE programs, and explore how the theoretical framework can help to understand these experiences. Topics will focus on exploring participants perceptions of the positive and negative effects of PCE experience on their FYE students, the influence of PCE on FYE group formation and teamwork, and how workshop participants currently address their students' transitions from pre-college to first-year engineering.

The second half of the interactive discussion will focus on brainstorming ways that both the individual programs represented by the workshop participants and the larger first-year engineering education community can promote better alignment between PCE and FYE. This includes exploring ways that FYE curricula can be modified or differentiated to acknowledge incoming students varying levels of exposure to and understanding of engineering, building connections between the pre-college and first-year engineering education communities, and encouraging participants to understand their local pre-college engineering landscape and explore how they can become more involved in shaping pre-college engineering education.

We envision this workshop as a way for first-year engineering instructors and course to designers to learn more about the current pre-college engineering landscape, provide participants with a theoretical framework they can utilize to understand the transition from pre-college to first-year engineering, and begin a larger conversation about how to better align pre-college and first-year engineering to better address the changing academic preparation of their students.

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