Special Session - A Framework for Engineering Student Innovation that Connects Cognitive, Psychological, and Cultural Aspects of Learning

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Abstract **– Engineering is inherently an innovative profession with design at the center of its core practices. Over the last decade, its importance for engineering students has heightened with the emergence of policy efforts and the rise of collegiate programs developed to support student innovation. Yet, research on how engineering students approach and experience innovation has been limited. During this special session, our goal is to present a framework for engineering student innovation along with research findings that informed the development of this framework. We will engage the audience in discussion of how this framework and related studies can inform teaching and student learning.**

Keywords **– cognitive; cultural; framework; innovation; psychological**

I. Goals of the Session

The purpose of this session is to present a research-based framework for engineering student innovation, and to engage researchers and educators in a discussion around this framework. More specifically, we aim to identify how this framework and results from related studies may inform teaching and learning in engineering education, with insights from the session participants based on their own experiences related to innovation and innovation education.

Toward that end, this session addresses four specific goals:

- Generate a list of innovation projects engineering educators use in the classroom and their observations on student experiences during these projects.
- Discuss cognitive theories that help describe how engineering students approach innovation, experience innovation projects, and conceptualize the innovation process.
- Present research on engineering students' approaches to innovation.
- Engage participants in a short data analysis session to promote discussion of data representing challenges students' face, experiences they find helpful, and strategies to help them become innovative engineers.

II. Anticipated Audience

We anticipate the audience of this session will consist of educators, researchers, and graduate students interested in promoting innovation among engineering students, including those who have developed innovation-specific student projects, conducted research related to innovation, or participated in innovation projects. Further, we anticipate that those new to the field of innovation will be able to provide novel insights and gain a quick understanding of the key literature and ideas in the field.

III. Session Rationale

Engineering drives innovation through the development of new processes and technologies. Hence, fostering innovation is an important goal of engineering education. The National Academy of Engineering also outlines innovativeness as an essential attribute needed for engineers. In contrast with the need and importance of innovation, recent studies show that engineering education does not always nurture innovative thinking. For example, in a study with engineering students, Genco (2010) found that undergraduate seniors in engineering were less innovative in their design solutions than their first-year engineering counterparts [1]. Another study, conducted by the Center for the Advancement of Scholarship on Engineering Education (CASEE), also compared first-year and engineering students and seniors. In their study, seniors perceived creativity to be less important for engineering than first-year students [2].

Higher education institutions have addressed these calls and concerns through the development of special programs. For example, many higher education institutions offer minors and certificate programs that allow students to learn about innovation [3]. The studies on the effectiveness of these programs are promising (e.g., [4]). Yet, the field has not developed a framework of student innovation that address diverse aspects of the student experience that

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support student innovation.

Based on a series of studies focused on engineering student innovation, we present a framework that asserts that innovation is influenced by diverse factors along cognitive, psychological, and cultural dimensions. The cognitive aspects of student innovation include understanding of the innovation process and cognitive abilities necessary to innovate. The psychological aspects of innovation include student motivation necessary to innovate and persist. The social or cultural aspects of innovation refer to learning environments where students engage in projects in or out of the classroom.

IV. Description of Interaction

This session will provide three key types of interactions. First, participants will have a chance to interact with other educators and researchers interested in engineering innovation. We expect this will allow them to share experiences and discuss diverse views on the topic. Second, participants will interact with the facilitators, who are also experienced researchers and educators on the topic of engineering student innovation. Finally, participants will interact with data from students through a data analysis task. During this task, participants will experience and analyze key interview excerpts of engineering students discussing their experiences with innovation projects.

V. Session Description

The session will start by asking teams of participants (4–6) to generate a list of project descriptions, instructional strategies they use, and examples of challenges students face when working on innovation projects. Next, we will cover a brief review of relevant literature and learning theories that help support aspects of some of the strategies mentioned and explain student challenges. This review will culminate in a presentation of the research-based framework for engineering student innovation.

We will then share anonymized data with teams of participants and engage them in a data analysis task. Teams will present the results of their analysis, which together will connect to the framework on student innovation. To prompt reflection, we will ask participants to reflect on their own processes, specifically addressing the potential overlap with the challenges student face during design problems and ways to develop milestones that can be applied across engineering domains.

VI. Session Agenda

The session will involve a variety of activities including collaborative group tasks and reflections as well as authors' presentations on the framework, related learning theories, and research findings.

Introductions: The authors will provide a brief introduction of themselves (5 min). Also, in small groups, participants will introduce themselves to each other and generate a list of innovation projects they use in the classroom and observations on student experiences during these projects (10 min).

Review of Literature/Framework: The authors will link the examples the participants generate to current literature on innovation education and theories of learning, cognition, and motivation. The authors will also present the framework for engineering student innovation. PowerPoint slides will be used (15 min).

Group Data Analysis Task: The participants will receive anonymized data that they will analyze in groups (40 min).

Reflection: There will be a discussion on strategies that support student innovation through a focus on cognitive, psychological, and cultural aspects of learning (20 min).

VII. Expected Outcomes & future Work

A key expected outcome of this session for the participants is an increased understanding of how research and theories can inform classroom applications. We also hope that this session will inspire future collaborations among the participants. Further, discussion during this session will provide additional insights related to the research-based framework and serve to check communicative validity.

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