KEEN Engineering Skillset and Competition Teams Success: Creating Value Through the Co-Curriculum

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KEEN Engineering Skillset and Student Competition Teams: Creating Value Through the Co-Curriculum

Engineering competition team projects provide students with the opportunity to apply learning from the technical classroom to real world, open-ended design projects. As Bland et al have observed, based on their research with students who participate on engineering competition teams, "engineering competitions may act as a catalyst for students to learn how to integrate technical and professional skills and knowledge in their development as an engineer [1]". In addition, engineering students' involvement in activities outside of the classroom, such as student competition teams, contributes to their achievement of numerous other outcomes; according to Simmons, et al, engagement with these activities enhances students' "career and professional development, communication and leadership development, intellectual development, personal and social development, academic and social engagement, intercultural competence, satisfaction with college experiences, and college belonging and persistence in major and college [2]". Working on a competition team, therefore, contributes to the development of students' design and build skills, as well as students' non-technical skills, skills that may or may not be a part of their technical coursework [3], [4], [5], [6].

While Simmons et al do not list the development of an entrepreneurial mindset (EM), an engineering competition is potentially a rich environment in which students can acquire EM. For example, the ASME Human-Powered Vehicle Challenge describes the nature of the challenge in this way:

> Human-powered transport is often the only type available in underdeveloped or inaccessible parts of the world, and if well designed, can be an increasingly viable form of sustainable transportation. ASME's international Human Powered Vehicle Challenge (HPVC) provides an opportunity for students to demonstrate the application of sound engineering design principles in the development of sustainable and practical transportation alternatives. In the HPVC, students work in teams to design and build efficient, highly engineered vehicles for everyday use—from commuting to work, to carrying goods to market [7].

As part of the competition, students must design their vehicle for multiple requirements,

including speed, safety, etc., with the evaluation of these elements performed through written design reports, visual inspections, and races. The actual design for the vehicle, however, is left to the student team, and it is an open-ended design problem like this that encourages students to cultivate a new mindset, one that is creative, independent, and, not coincidentally, entrepreneurial.

KEEN Competition Team Skills Project Context

The connections between engineering competition teams and EM have yet to be explored in the engineering education research literature. In our project, we seek to understand the inter-relations between engineering competition teams and EM by focusing on the KEEN Engineering Skillset (KES) which is part of the EM framework (see Figure 1). A comparison of the KES to the competition team context suggests that KES maps well to competitions in some cases (e.g., the skills listed in the Design category), but maps less well in others (e.g., skills listed in the Impact and Opportunity categories). For example, during an initial focus group with Rose-Hulman Institute of Technology faculty who mentor competition teams (June 2019), there was general agreement that some items in the KES aligned well with the competition teams context, while there is distinct misalignment with others:

- **Create a business model**—while the faculty interviewed did not see the phrase "business model" as appropriate to the engineering competition context, they stated that competition teams generally need to construct an operating model to help them organize and work together effectively;
- **Identify a supply chain—**in order to keep their projects on schedule, student teams need to establish a supply chain (for materials, etc.) early in life of the project;
- **Protect intellectual property**—faculty expressed that the underlying spirit/ethos of competitions is generally to share resources and help each other. Without this spirit, teams won't grow and learn. As one faculty mentor stated, "Protecting IP is anathema to many competitions";
- **Assess policy and regulatory issues—**faculty translated this skill into the need for teams to assess the competition rules, then deal professionally with judges/officials;
- **Opportunity generally—**while faculty did not see the competition teams context as a

place for students to identify an opportunity to create a business, they agreed that the competition provided the problem to solve, but students needed to determine what their "edge" is in the competition;

- **Communicate—**this skill had several applications in the competition teams' context, including inspiring other students to join the team, champion the project, and document what was learned in the previous year in order to sustain the project from year to year.

Figure 1: KEEN Engineering Skillset [8]

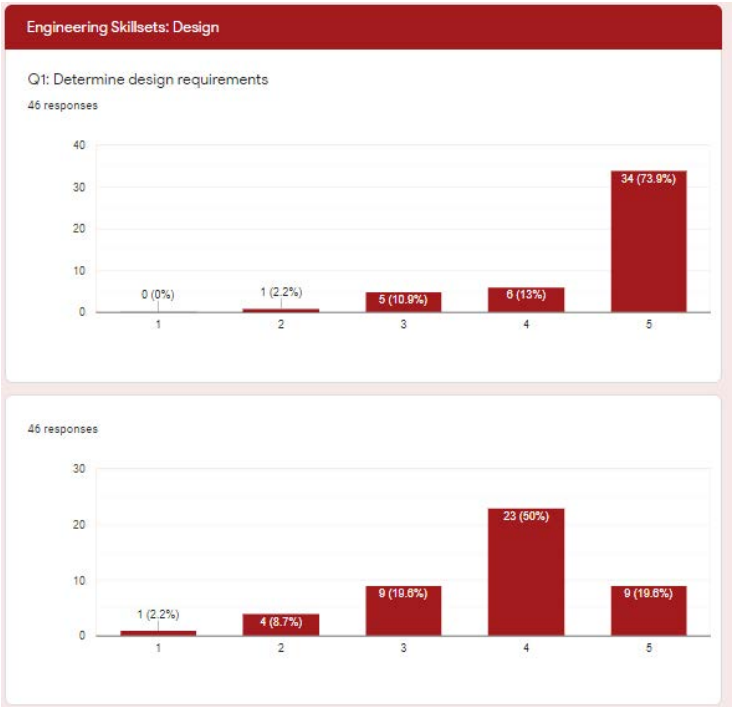
In the first stage of our project, we created an online survey in order to expand on our initial focus group session with faculty from Rose-Hulman. By inviting faculty who mentor or advise engineering competition teams at colleges and universities in the KEEN network, we hoped to

achieve two objectives: 1) to demonstrate the alignment between the skills students need to be successful on engineering competition teams and the skills identified in the KES; 2) to adapt the KES to the engineering competitions context by revising and/or adding to the KES to create the KEEN Competition Teams Skillset. We envision that the impact of this revised skillset will be to help faculty and engineering students see the significance of competitions to students' development as successful engineers who possess both superior technical and non-technical skills, including EM.

Survey Development and Deployment

To begin this project, we developed an online survey and identified individuals from institutions within the KEEN Network who advise/coach student competition teams. We invited 99 individuals to respond to our survey and received 42 responses. The survey instrument listed the 18 KES, organized into three groups: Design skills, Opportunity skills, and Impact skills. For each skill, respondents were asked two questions: 1) How important is this skill to students' success on a competition team (5=Very Important, 1=Not Important), and 2) how capable are they currently of demonstrating this skill (5=Very Capable, 1=Not Capable). Respondents were asked to use a 5 point Likert scale to rate their responses to the two questions (see Figure 2). In addition, respondents were asked to add additional comments to each skills section.

Figure 2: Survey Response Sample



At the end of the survey, we listed the all of the KES and asked respondents add to the list of KES by providing important skills that were currently absent: "Please use the comment box to add any skills that you believe are important for student success on competition teams but were not listed above."

Following the closing of the survey, we conducted a series of online interviews with 10 faculty respondents. The purpose of the interviews was to dig deeper into their responses in order to determine the relevance of the KES to students' work on competition teams. What we heard in the interviews confirmed the survey responses about skills students need that are not currently a part of the KES, such as project management, leadership, teamwork, and communication. In addition, we heard from faculty that they would appreciate having access to resources that they could share with students to help them develop these skills if they do not come to the competition team with those skills already in their possession; some respondents indicated that the courses designed to prepare students for design, such as a junior-level design course, were sometimes not adequate to prepare students for the real-world setting of a competition team and its associated demands. As a result of our work with the survey and interview data, we are in the process of creating the KEEN Competition Teams Skills Map, which adapts the KES to the

competition team context, revises some of the KES skills and adds skills that are not yet a part of the KES. Our plan is to have this Map in draft form and ready for review at the 2020 ASEE Conference. One interesting outcome from our work has been a suggestion for a Competition Team Roadmap, a guide for faculty advisors who are taking on advisor duties for a competition team for the first time. The Roadmap could highlight the stages of a competition, identify where students are likely to struggle, and connect faculty to resources that they could share with their students. These resources could be in the form of online modules for topics like project management, conflict resolution, team members recruitment, and other skills that faculty believe are essential for their students' development and competition success.

KEEN Competition Teams Skills Map Development

As a result of this project, we are in the process of designing the KEEN Competition Teams Skills Map, which we believe will provide students and faculty who are involved with competition teams with guidance on the skills that contribute to both competition success and the development of an entrepreneurial mindset. We see this project contributing to both the development of students' skills in the competition team context, but also their development of an entrepreneurial mindset.

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