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Active Participation of Industry in a Community-Engaged Design Program

Andrew Pierce, Purdue University, West Lafayette

Andrew Pierce is the Assistant Director of the EPICS Program at Purdue University.

Dr. William "Bill" C. Oakes, Purdue University, West Lafayette

William (Bill) Oakes is a 150th Anniversary Professor, the Director of the EPICS Program and one of the founding faculty members of the School of Engineering Education at Purdue University. He has held courtesy appointments in Mechanical, Environmental a

Robin D. Terwilliger, Purdue University, West Lafayette
Jorge Martinez, Purdue University, West Lafayette

Active Participation of Industry in a Community-Engaged Design Program

Abstract

A community-engaged design program at a large public university partners teams of undergraduate students with local or global community organizations to design, build, and deliver real solutions to the community. The program creates three-way partnerships between the university, community, and industry by engaging corporate partners as advisors (instructors), mentors, and design reviewers. Local industry representatives volunteer their time to help teach the course. Corporate representatives are mentored in teaching design-based community engagement courses and serve as instructors of record for several sections. Others provide mentoring on specific topics or with teams. The most significant number of corporate volunteers are engaged in the twice-per-semester design reviews. To ensure quality deliverables, the program has long hosted design reviews, in which volunteers from industry serve as expert panelists, listening to the student teams' presentations and giving feedback and suggestions to improve the projects and support the students' professional development. Engaging industry in design reviews has led to a number of positive outcomes, including translation of the more engaged design reviewers into volunteer team advisors, closer connection with industry partners yielding financial sponsorships, and more opportunities for students to engage with potential employers. As the program has grown over its 28-year history to more than 1300 students per year, the need for design reviewers has grown with it. This paper describes the system employed to facilitate industry engagement as advisors, mentors, and design reviewers. Results are shared from industry volunteers and student reactions.

Introduction

Preparing undergraduates for a successful transition into professional practice is one of the main goals of engineering education. Prior studies have found employers asserting that undergraduate engineering programs do not adequately prepare early-career engineers for work in engineering practice [1] and that engineering curricula can be misaligned with engineering practice in fields such as software engineering [2]. Studies have examined student perceptions of their engineering curriculum and suggest that students consider engineering practice rather than their experiences in academia "real world,". They fail to understand how their classroom activities prepare them for professional practice [3]. In a longitudinal study with 160 engineering students at four universities, Matusovich, Streveler, Miller, and Olds found seniors were still uncertain about what it means to be an engineer, and what engineers do in practice [4].

James Trevelyan advocated the need to change engineering curricula to better prepare students for the transition into industry [5]. Winberg et al conducted a systematic literature review of the research literature on engineering employability, curricular and pedagogical arrangements that prepare graduates for work in the twenty-first century [6].

Many reforms have been developed that integrate industry and academia and engage students in industrial practice and/or representatives from corporations into the academic experience. Male

and Kind described an approach that engages members of industry into their curriculum to better prepare students for their transition into industry [7]. Industrial scholars' programs can bring mentors into contact with students [8]. Mann et al discussed how the program at Swinburne University has moved from a problem-based learning model to practice based to enhance preparation of graduates for industry [9]. The model for Iron Range Engineering, which was the first experiential learning ABET accredited engineering program, has followed a similar trajectory, moving from problem-based learning to practice [10] that was informed by the models of practice-based education at Charles Sturt University [11].

Another approach to professional preparation is engaging students in authentic experiences that are connected to community-based projects and experiences. Data from the EPICS Programs showed that graduates gained valuable experience from their community engagement experiences that translated into engineering practice [12]. Community-engaged learning has additional benefits including increases in retention [13] [14] [15] as well as addressing issues of diversity within the engineering population [16] [17] [18]. This paper will describe a community-engaged design program and how it has engaged industry and corporate representatives to enhance their professional preparation and the capacity of the program to meet needs of the community partners.

Overview of EPICS Program

The EPICS program has been engaging students with local and global community partners for 28 years. EPICS is a design course with the express goal of connecting engineering students, who needed opportunities to gain real-world experience, with community organizations, who needed assistance keeping pace with the rapidly changing landscape of technology [19]. This symbiotic relationship quickly flourished, resulting in major impacts to all parties involved. Students who participated in the EPICS design courses were able to practice their disciplines in an authentic, hands-on environment while developing their professional skills and bridging their academic experiences toward workplace practice [12]. As the program has grown and expanded to more students, projects, and instructors, the students' opinions on the programs impact has remained at a high level [20]. The community organizations likewise have benefitted greatly from these partnerships, benefitting from the university's expertise in technology and the creation of new products and processes that support the organizations core mission [21]. The success of the EPICS program was recognized by other institutions who have integrated this model of community engaged design at the university and K12 levels [22]. Likewise, within Purdue University, the program has grown beyond the bounds of engineering, welcoming students from more than 70 majors across all colleges, established a first-year learning community, and has been adopted in the core curriculum and in many minor and certificate programs across the university.

While the reciprocal partnership between the university and community organizations was fruitful from an early stage, a third partner group came into play that further enriched the collaboration for all parties. The co-creation of new technology between the community and the EPICS teams necessitated both funding to purchase supplies and the expertise of practicing

professionals. Connecting with industry partners served to provide a source that could satisfy both of these needs [23]. Unlike many university design programs that partner with industry to do projects tied to the core business of the industry partner, EPICS took a different approach. In the EPICS partnership model, industry partners benefit from enhanced community relationships through their support of and participation in community serving projects, as well as exposure to a large group of students with real experience that represent a potential hiring pool. Instead of working on projects for their business, the industry partners provide financial support to projects through team sponsorship. Instead of focusing only on financial benefit, the industry partners are also engaged in providing valuable skills and advice to the teams by serving as volunteer instructors in the classroom, design reviewers, or subject matter experts. Thus, a three-way reciprocal partnership is formed, in which all parties benefit tangibly from their engagement with the EPICS program.

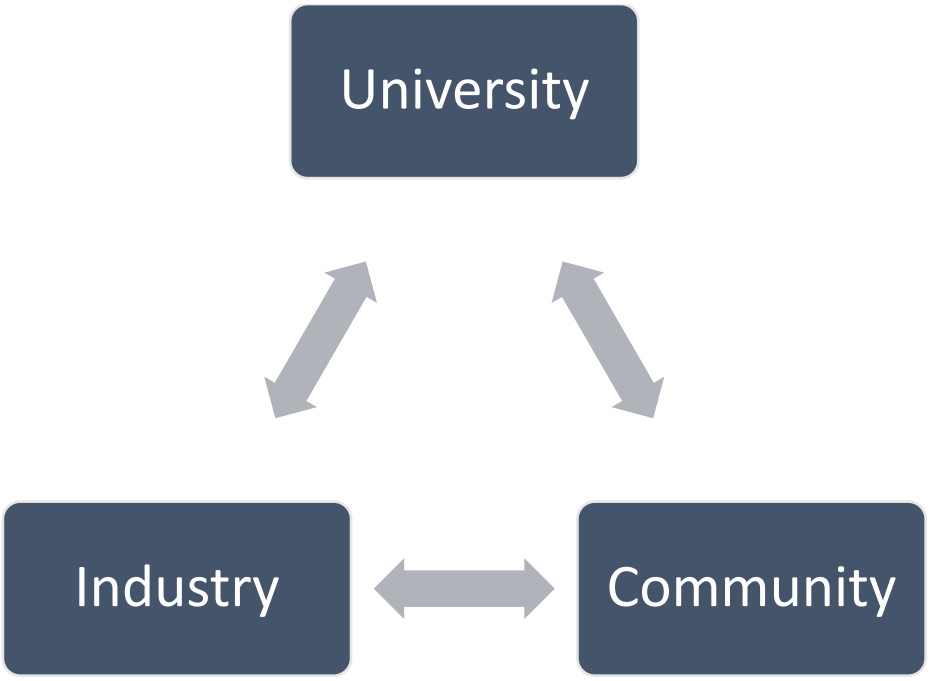

Figure 1: Three way reciprocal partnerships through EPICS

Sponsorship

The most traditional form of industry engagement with community organizations is through direct financial contributions. Corporations in the United States donated more than $21 billion dollars to charities and community organizations in 2021 [24]. In the three-way partnership model employed by EPICS, industry funding typically flows to the student projects in the form of team sponsorship, in which a corporate partner provides fixed financial support to a team over a period of time. The student team then uses this funding to purchase the supplies needed to fabricate the prototypes and a final deliverable that is ultimately utilized by the community

partner to add assets to their communities. As part of the team sponsorship, the team will feature their sponsor on their website and social media accounts, and the EPICS Program features them prominently on the enterprise website as well as on main hallway screens outside the labs.

Team Advising and Subject Matter Expertise

The EPICS program at Purdue University has 45 unique teams as of the Spring 2023 semester, with more than 600 students participating per semester. Most commonly, teams have multiple projects, focused either around a common community partner or a common theme. For example, one team conducts multiple projects with the local branch of Habitat for Humanity, whereas another team develops web-based database systems for a variety of different community partners. Each team has a historical average of 15 students and multiple projects, typically with four to five students per project. Each team stands as an independent lab division, but with a common curriculum, syllabus, and assessment. As a student-centered, project-based course, instead of serving as a lecturer, the instructors in each lab division serve as a coach or guide and are thus labeled as 'advisors'.

Early in the formation of EPICS, it became clear that one bottleneck to program growth was the limited capacity of faculty to advise teams. One solution employed to address this issue was to recruit volunteer advisors from local industry. These advisors were mentored by the existing faculty and staff advisors to learn the fundamentals of working within the university structures. One hard-learned lesson was to establish these volunteer relationships with the individual volunteer as well as their management. In industry, there is little tie to the academic calendar, and employees may transfer or move at any time in the calendar, which can present a significant challenge in the classroom as the team is left without an advisor. A formal or informal understanding can be established with a volunteer's management chain, such that if such an interruption is to occur, the employer can provide a substitute advisor. Likewise, it has become a common practice when possible to have two advisors on many teams, such that if one has an interruption, the other can provide continuity to the team.

Some industry partners do not have time to commit to advising teams but are interested in engaging with students on-demand. Industry members often have key skills that students lack, and so having a designated expert for students to consult with has proven valuable. Students are directed to contact these volunteers directly when they have a technical issue that they need assistance with, and the volunteers work one on one with students or project teams to mentor them through the relevant portion of their design work. An example of such an arrangement is an employee of a local printed circuit board (PCB) design company will review and provide feedback to PCB designs that EPICS teams create before having them fabricated.

Design Reviews

The final and most common way that industry engages with EPICS is by serving as design reviewers. Two sets of design reviews are conducted each semester, one at the midterm and one at the end of semester. During the design reviews, each student team will present on their project work, walking the reviewers and partners through their progress in the design process, from project initiation through their current state. During the presentations, the design reviewers will

ask probing questions and provide feedback on the team's work. The feedback can cover the spectrum of relevant material, including technical work, customer engagement, project management, and more. These reviews serve a quality-control function, ensuring that the deliverables generated by the team will be of high quality and meet the needs of the community partner. To facilitate reviewers from a large geographic range, remote conferencing capabilities are utilized as a hybrid in-person and remote meeting.

The logistics of conducting design reviews for a large program are complex, including the process of recruiting and registering design reviewers. Over years of recruitment, the EPICS program has generated a database of volunteers, including members of local industry, retirees, and alumni. Several weeks before each design review, an email invitation is sent to the database with a registration survey for the reviewers to indicate which teams' presentations they would like to attend, and then this is repeated in the week leading up to the review. The registration survey includes a non-disclosure agreement to protect students' ability to maintain control of their intellectual property. Additional design reviewers are sought through social media, word-of-mouth, and by the student teams, and all newly registered reviewers are added to the existing reviewer database.

Participation numbers

Reviewer participation for the six design reviews held during Fall 2021, Spring 2022, and Fall 2022, was an average of 120 unique volunteers who review from one team up to a full day and in some cases multiple days of presentations. In the Fall of 2021 and Spring of 2022, the reviews were fully remote and moved to hybrid reviews in the fall of 2022. All of the classrooms were equipped with video capabilities even before COVID and hybrid is a return to pre-COVID models, although the number of remote reviewers has increased. In addition to the reviewers expertise, nearly 2,500 hours of total volunteer time was given in the design review process.

Table 1: Number of Reviewers for each design review session

SEMESTER	# OF TEAMS	UNIQUE REVIEWERS	REVIEWERS IN ALL SESSIONS	HOURS
FA21 MID	42	121	173	346
FA21 FINAL	42	108	221	442
SP22 MID	44	85	130	260
SP22 FINAL	44	147	269	538
FA22 MID	44	149	264	528
FA22 FINAL	44	109	182	364
	Total	719	1239	2478
	Average	120		

Industry Engagement – Student Perspectives

Following the final design review in the Fall 2022 semester, a survey was sent to both students and to industry partners to gauge how each group viewed the value of industry partnerships. A

limitation of this study is that the community partners were not surveyed, as the relationship between industry and the community organizations is mostly indirect.

The student survey contained both Likert-style and free response sections. The Likert-style section asked the students to rate seven questions on the value of industry engagement for their personal development and team success. Five of these questions map directly to the assessed course outcomes: accomplishing project goals, utilizing the design process, teamwork/leadership, reflection and critical thinking, and communication, and the other two addressed one issue important to the community organizations, the quality of the deliverable, and the other an issue important to students, their ability to interview well for internships, co-ops, and careers. The free response area asked students to comment on the benefits of industry engagement for their personal development, project success, and community partners.

Of the student respondents, the majority of students were first year students (Figure 2) from the College of Engineering (Figure 3) and were taking EPICS for the first time (Figure 4). These factors are important, as older students who may have experienced industry environments through internships or co-ops or students repeating EPICS multiple semesters may have a more informed view of the value of these reviews than their less experienced counterparts.

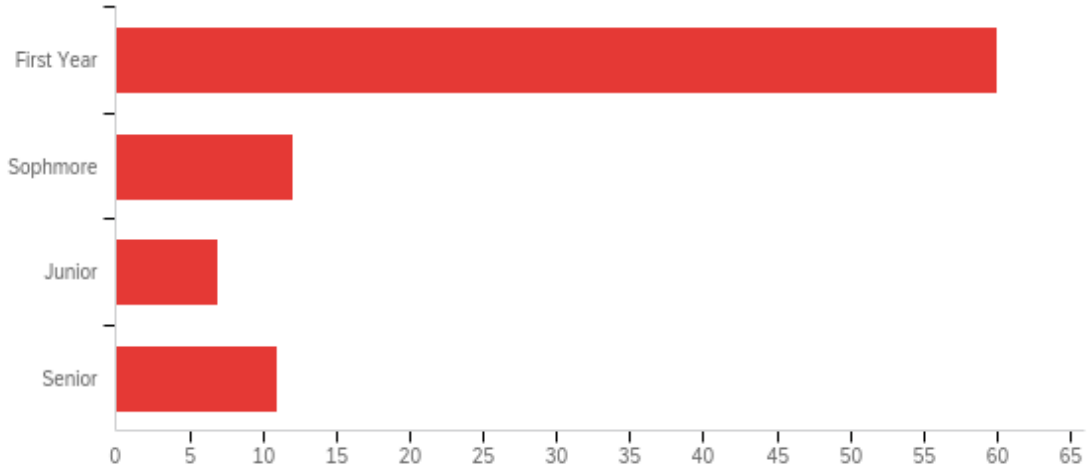

Figure 2: Student respondents by course level

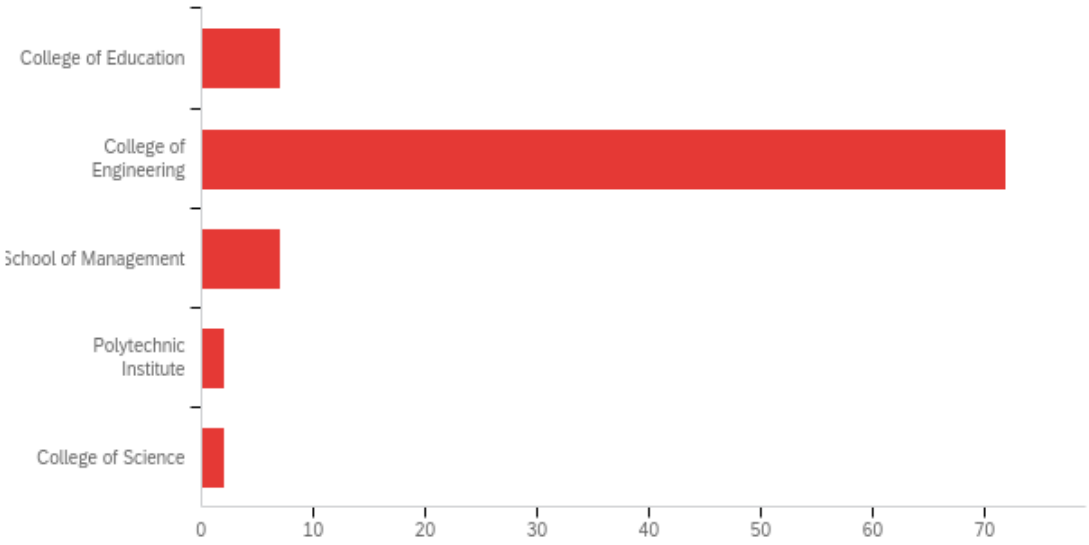

Figure 3: Student respondents by college

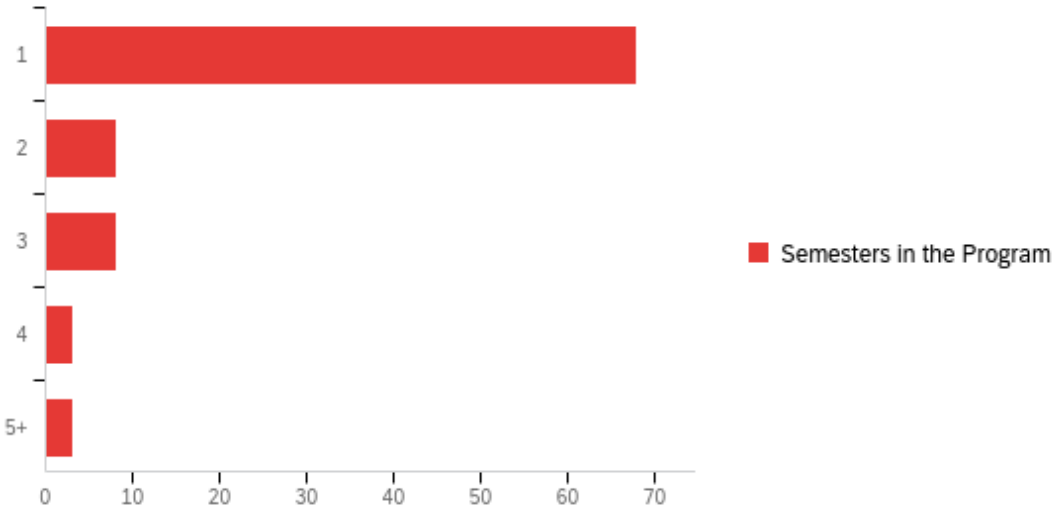

Figure 4: Number of semesters the student has taken EPICS (including the current)

On the Likert-style section, students overwhelmingly indicated that industry engagement provided a range of benefits (Figure 5). The students could clearly see the value of industry partnerships in advancing the five assessed course outcomes, which the large majority indicating they somewhat or strongly agree that the industry engagement improves their success in each of these areas. Likewise, the students responded strongly in support of industry engagement improving their final product quality, supporting the idea that design reviews and industry engagement in general serves a quality control function. Students were generally positive, but less clearly supportive, of the idea that their engagement with industry partners has improved their interactions with companies during interviews. This may be at least in part a result of most

of the respondents being first-semester college students, and so may have never had an experience interviewing with a company.

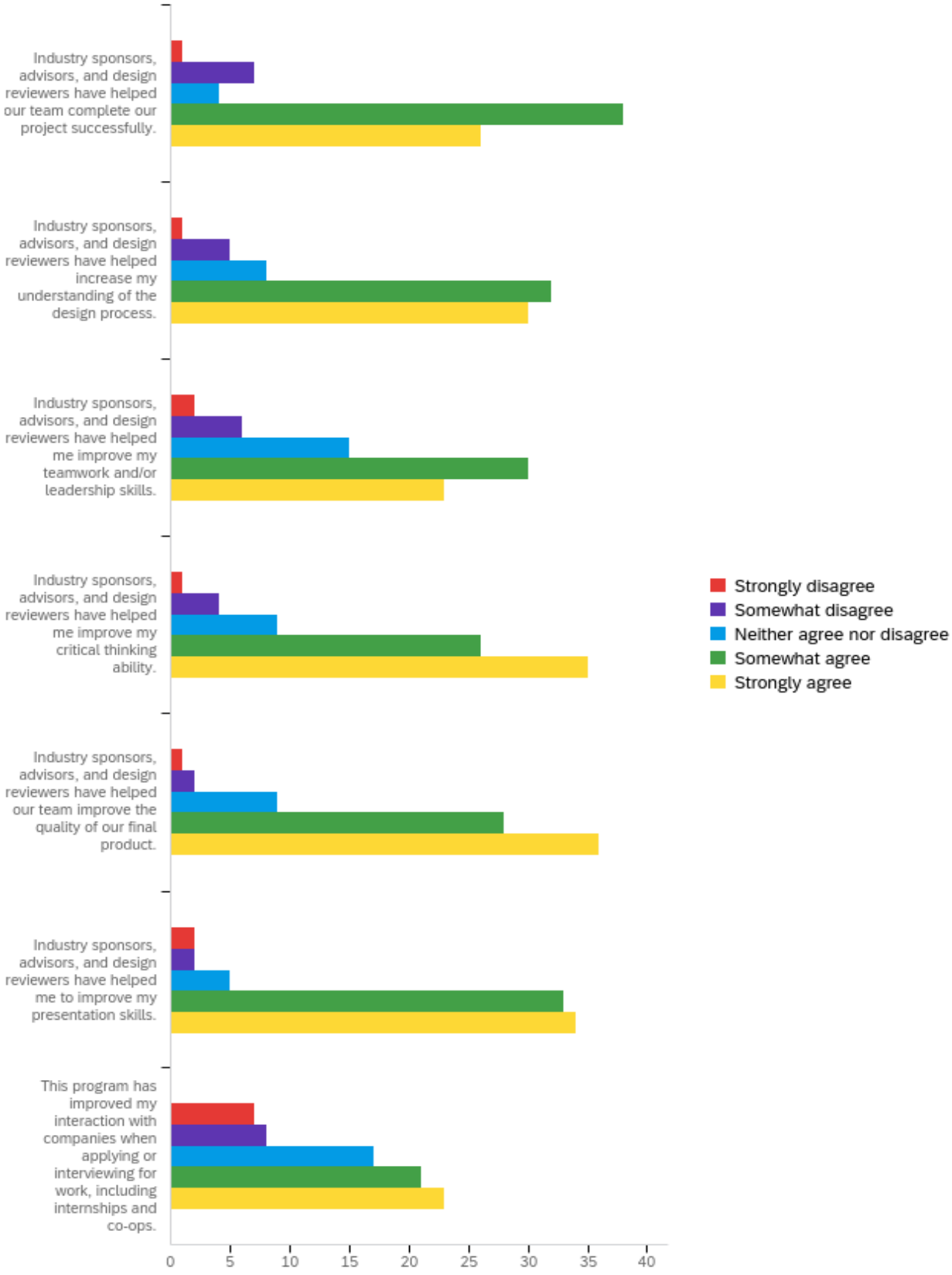

Figure 5: Student survey Likert-style responses

In the free response section, the student respondents indicated that their engagement with industry partners was a benefit to their personal professional development. One common thread was that the experience of interacting with industry improved their professional communication skills. A sample quote from a student said:

> "I was able to see how important communication is between various people. I had to talk back and forth between the zoo and multiple teams as well as my own teammates. I matured throughout the semester and learned so much especially with the great feedback the design reviewers gave our team."

> "I have become more efficient at preparing and answering questions about my process to show my best understanding of the project. This especially has helped me with interacting outside of EPICS, such as with interviewers."

Another common thread was that interaction with industry provided positive feedback that the design material they were learning was in fact useful beyond the university, for example:

> "Design reviewers are always very supportive of the EPICS design process, and this acts as validation for me and for EPICS this process works in the industry. So it has really solidified this EPICS design process in my mind as universally correct, which will help me in my career."

In regards to impact of the industry engagement on their project progress, students were likewise positive. Students recognized that industry engagement helped ensure the team stuck to the design process and provided perspective and experience that they lacked.

> "Our project has improved tremendously because we were able to recognize certain details of the project that needed more attention or needed improvement that we did not realize before. By engaging with industry partners and design reviewers, we gained outside perspectives on our product and how we can make it more safe and efficient."

Students also recognized that industry engagement with their team positively impacted their community partners. The main effect that students perceived is that the feedback they received from industry improved the safety and quality of their deliverables.

> "My community partner has benefitted by my team's engagement with industry partners, because they are getting high quality products (tested and reviewed by professionals)."

> "Our community partner, based on our engagement with industry partners and design reviewers, understands how much time and effort my team is putting into making our product as safe as possible with the utmost quality. They have learned more about how much work we have put into the project and are very excited to receive it since they know how closely it follows their mission statement that we have followed during the design process."

Industry Engagement – Professional's Perspectives

The professional survey also contained both Likert-style and free response sections. The Likert-style section asked the professionals to rate their agreement on four questions, focused on areas of impact, including the students, community partners, their employer, and themselves. The free response questions sought to gather further insight into the respondents' perceptions of each of those impact areas.

Of the industry respondents, 10 out of 14 were Purdue alumni (Figure 6) and of the Purdue alumni, six out of ten had taken an EPICS course as a student (Figure 7). This is a much higher representation of program alumni than the pool of professionals engaged with the program, and may be a result of program alumni being more willing to respond to a survey from EPICS. The most common mode of engagement was as a design reviewer, but three of the 14 had also served as team advisors (Figure 8). Again, there is a higher representation of team advisors, and it may be that the professionals who made this larger time commitment were more likely to respond to the survey.

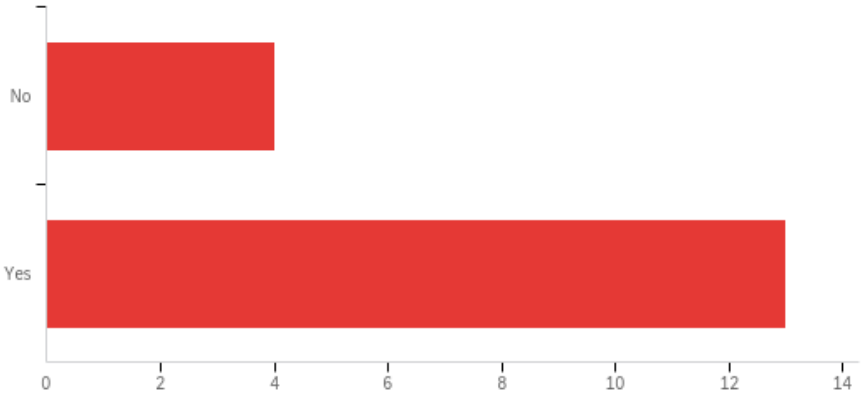

Figure 6: Industry respondents' alumni status

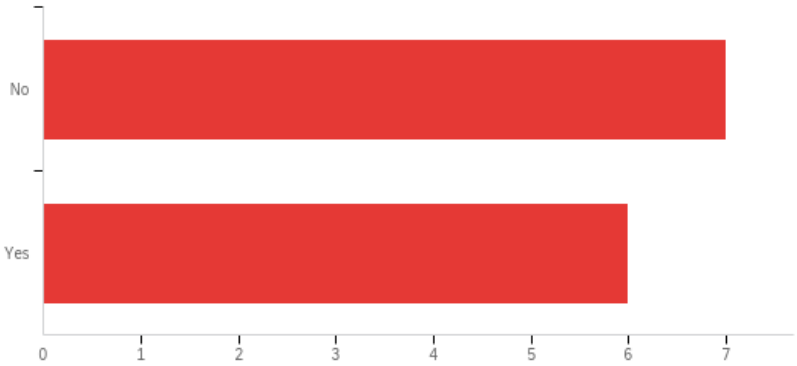

Figure 7: Industry respondents who had participated in EPICS

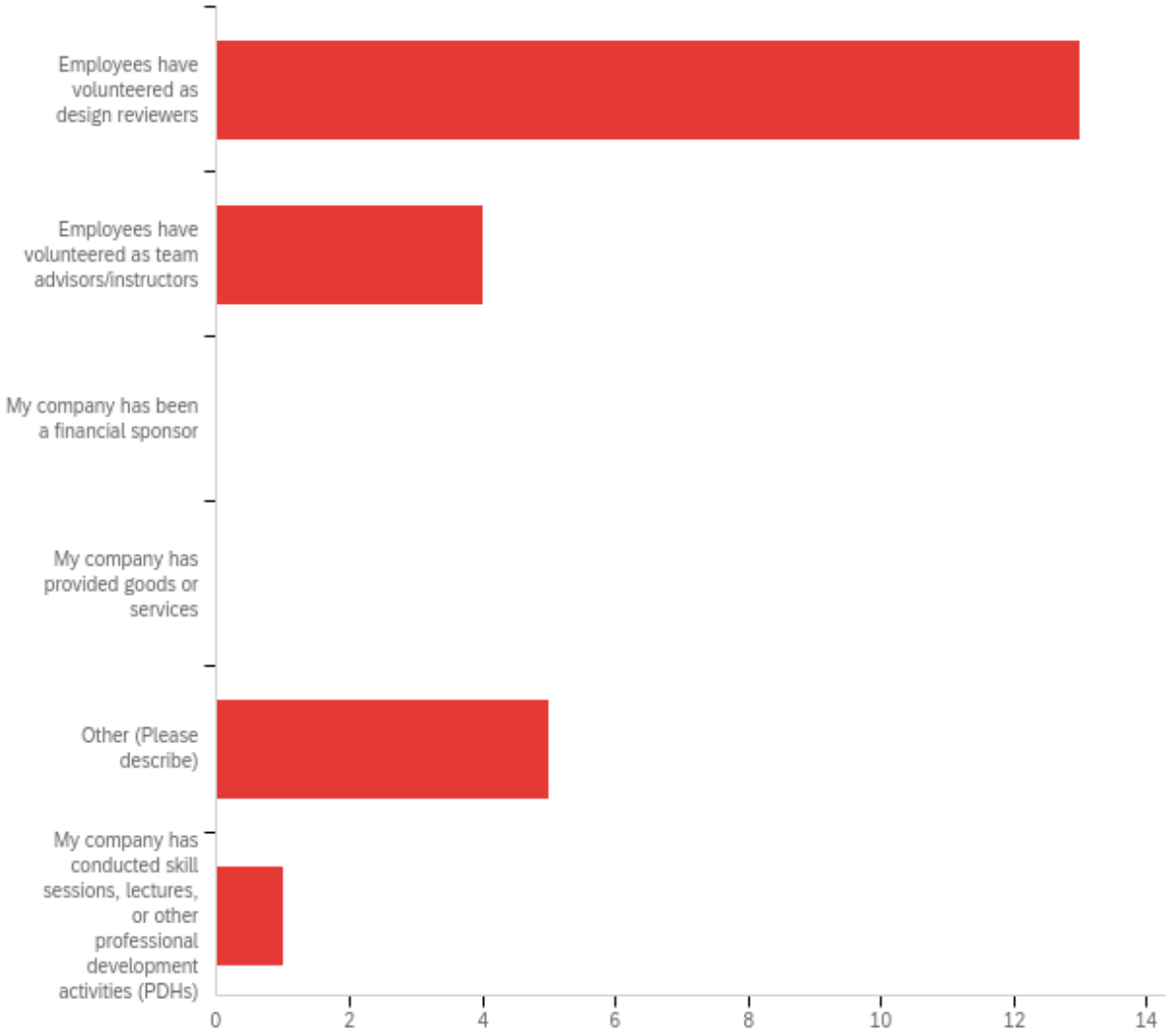

Figure 8: Industry respondents' corporate engagement with EPICS

On the Likert-style section, the industry respondents indicated a positive impression of the impact their engagement has on the program (Figure 9). All respondents indicated that they believed their participation improves the educational opportunities for the EPICS students. Likewise, there was strong agreement that their participation helps the teams provide a more significant impact on the community organizations. The results were more mixed on the respondents' view that their participation was valued by their employers or that it advances their personal professional development. This may be influenced by the career level of the respondent, as the early career professionals may see these opportunities as more formative than their older colleagues.

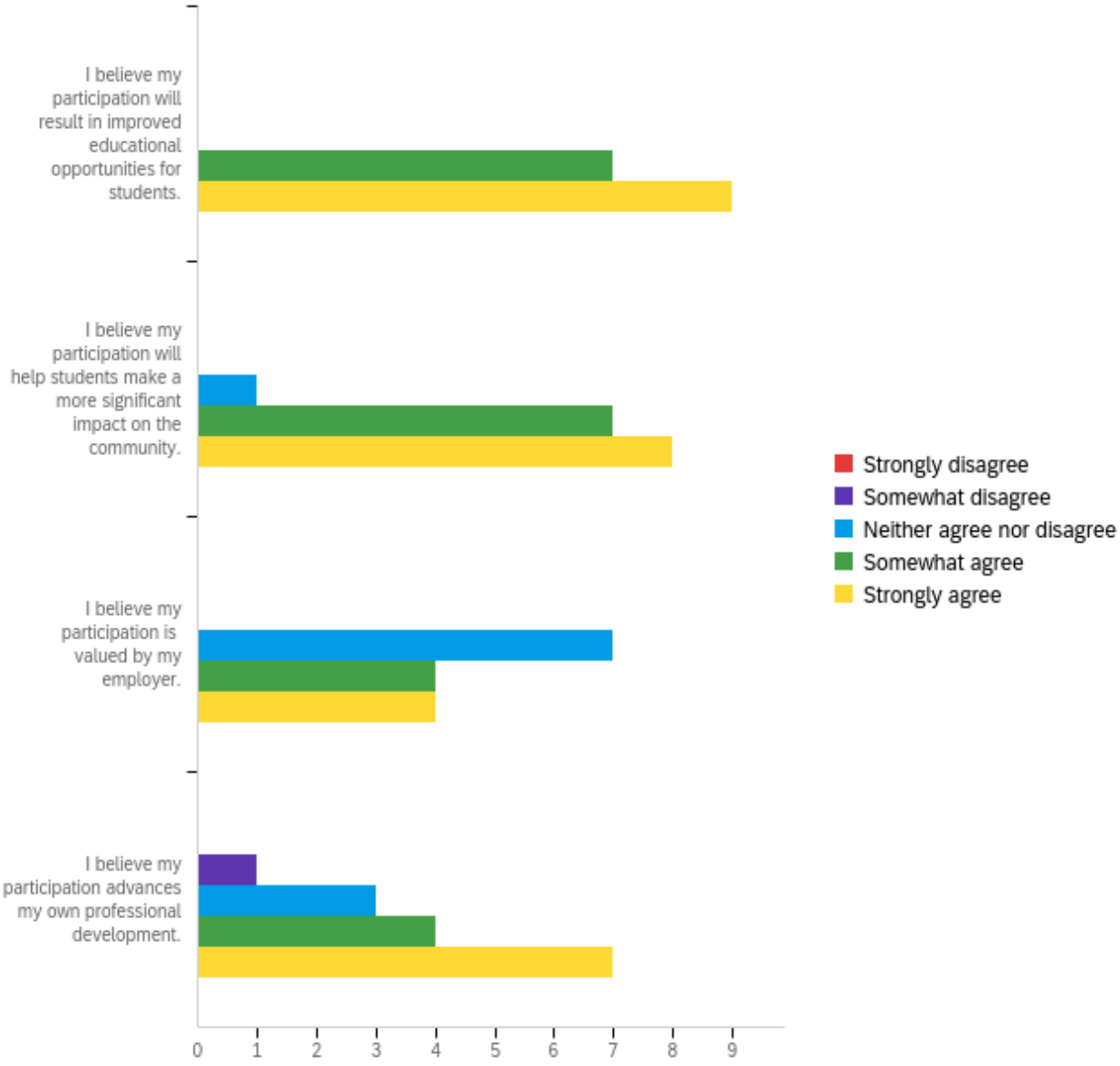

Figure 9: Industry respondents' perceptions of their impact

In the free response section, industry respondents commented on their motivation to engage with EPICS. Two common threads that emerged were that industry professionals engage with EPICS as a means to help the teams be effective in helping the community, and that interaction with EPICS students was a means of exposure to a talent pool for recruitment.

> "I like being able to provide real world feedback to reviews. This allows the teams to work on improving their projects or it provides affirmation that they are on the right track."

> "Participating in EPICS design reviews is a good way to interact with future potential employees and give current students some exposure/awareness to our company."

Many of the respondents were EPICS alumni, and it was clear that in reflecting on their experience, they saw the value that reviewers had provided to them in their professional growth and formation, and they desired to continue to provide that opportunity to future students.

> "EPICS played a significant role in my career. I participate with EPICS because I feel it is important to give back to something that helped me so much."

> "I can only speak for me, but as a former student who was in EPICS for all 4 years of undergrad, I really appreciated the thoughts and opinions from outsiders (not just the EPICS and team advisors) who have experience in some of these fields. They provided us some invaluable comments on how to better our designs. I would like to come back and participate again to help "return the favor" for all those who came and participated in all of my team's reviews over the 4 years."

Regarding the industry respondents' view of how their engagement helps the students, the dominant theme was that outsiders to the university, particularly those with 'real world' experience, offer a perspective that the students cannot find within the confines of the university.

> "Input from industry during design reviews can help students understand challenges often faced in industry aren't necessarily technical (as I thought when I was a student) - sometimes communication or having clearly understood project requirements can be a larger challenge. Questions and input from industry can help highlight this and give students different perspectives."

> "Students can get a better understanding of what it actually possible, when their ideas are a bit too far fetched for what can be accomplished with the tools and resources available to the students. They can also learn more about the design process from those in industry that have worked on large scale product designs and launches."

> "Students can benefit from hearing the point-of-view of current professionals on their designs and plans. Hearing the advice of those now outside of the academic side helps them see what the professional side will expect to see from their work."

Similarly, the respondents saw the benefit to the project success comes primarily from their outside perspective. Respondents noted that their experience in industry helps them to identify shortcomings in the projects or in the process used to develop them that students and faculty may tend to overlook.

> "The design reviews are an opportunity for students to summarize and document project status and highlight progress. Having external (industry) engagement from folks who haven't been involved in the project previously require the students to communicate clearly and concisely; and they may take it more seriously as compared to if they were just reviewing with their classmates. Input from industry can also bring different perspectives that students may not have considered to result in a better project result."

> “The projects could have the potential to be more successful and the results have the potential to be more durable as the advice from industry partners could help the students predict any potential glitches or product failures so that they don't occur after delivery.”

> “Getting input from industry can help students view their projects in a bigger-picture role, as opposed to seeing and treating them as another classroom project. This helps the projects become more useable and successful at the community partner.

The final open-ended question asked the industry respondents what they thought were the primary benefits of their engagement for the community partner. They noted that their oversight ensures the project quality, and that the participation of industry members should provide the community partners with a degree of peace of mind with respect to implementing the students designs.

> “The EPICS projects get some additional oversight from various engineers that are in industry. This helps ensure products are well thought through and safe for use by the community partners' intended users.”

> “The community partners would hopefully receive more polished, durable, and "professional" looking/functioning products that will last longer. Also the community partners will have more trust in the EPICS teams that they truly are working to help them and providing them with solutions that are actually helpful, and not glitchy or defective, which wastes their time.”

Conclusions

A three-way partnership between a university design program, community organizations, and industry partners is described and can serve as a model for such reciprocal partnerships. In this model, each partner contributes to the overall success of the venture while benefiting tangibly from their investment of time and resources. The outcomes and benefits of such partnerships for students and community partners have been previously reported [12] [19] [20] [22], but the engagement of industry partners has not been as well-characterized.

Within the context of this three-way partnership, members of industry engaged in the program in a variety of different ways. The most common method was as a design reviewer, providing feedback to teams during formal presentations held twice per semester. Other members of industry engaged in a more time intensive volunteer role, supporting teams as a classroom instructor or advisor, or served in a recurrent consultant type role. Still other industry partners engaged primarily through financial support of the program and projects to ensure affordability for the community partners.

In assessing the value of industry engagement in these partnerships, both the students and industry volunteers found great value to the partnership from industry involvement. Students indicated that industry involvement aided them in improving their performance in five core

course outcomes, as well as increasing project deliverable quality and gaining additional employability skills. Industry members likewise perceived an improvement in student outcomes, community outcomes, and a net benefit for themselves and their employers through their engagement. This partnership model could be adopted by other programs to increase participation of industry members in their programs.

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