Integration of a First-Year Learning Community with a Vertically-Integrated Design Program

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Introduction

Getting students to experience the excitement of engineering has been a goal for first-year engineering programs to increase the number and diversity of students who earn engineering degrees. These efforts have included programs targeted at special populations with the creation of minority and women's programs in engineering, technology and science; summer and outreach programs for K-12 students; summer bridge programs and larger curriculum reform efforts including integrated curricula and learning communities[1]. Earlier design experiences have become more common and have shown to be valuable in motivating students to continue in engineering programs[2]. A challenge with first-year design experiences is a lack of engineering expertise. Often students' designs are scaled down to the level of a first-year student but it strips out aspects of mathematical analysis and more complex design decision making. It lacks the attributes that distinguish engineering design from other areas such as technology design[3].

Additionally, design is often taught within traditional engineering challenges that are not necessarily aligned with characteristics to promote diversity. Approaches that have been cited in the literature as positive steps toward encouraging women, for example, to stay in engineering and STEM fields include framing science/engineering in its social context; stressing general educational goals, including communication, in engineering education; employing cooperative, interdisciplinary approaches; and undertaking problems with a "holistic, global scope" [4-6]. Research that has been conducted suggests that many of the same factors are relevant for attracting and retaining minorities[7,8]. A pedagogy which integrates these aspects and has proven to be effective in enhancing learning is service-learning[9].

Sue Rosser challenged the American Society for Engineering Education during her address as a Distinguished Lecturer at the 2002 ASEE Annual Conference to rethink the way in which STEM students learn as a significant step to address the issues of underrepresentation. She outlined how the time was right for rethinking the curricula in STEM fields. In engineering, ABET's EC 2000 provided an opportunity to redesign the curricula to capitalize on existing literature to reduce the barriers for underrepresented populations within science and engineering[5]. She provided an outline of what is known about science education and how it can be transferred across STEM disciplines. In the discussions following her address, she specifically identified service learning as one potential means of integrating important aspects into the core undergraduate curricula.

Another challenge is that most design courses are confined to one academic period (e.g. semester or quarter) and are intended to give the students an intense exposure to the design process in a single engineering discipline. The short schedule reduces the likelihood that students can experience the entire design process and there is pressure to avoid significant iteration cycles that could delay the completion. First-year students often do not understanding the differences between the disciplines and would benefit from an opportunity to explore multiple aspects of engineering. A longer experience could afford students the opportunity to explore different roles and even aspects of different disciplines.

Programs that allow students to explore options and interact with upper division students are often extra programs that are added on to the traditional curriculum. These include seminars or extra-curricular programs that add onto the already full student load. Ways to integrate these attributes into the curriculum could create efficiencies that would benefit students.

This paper explores an approach that integrated a vertically integrated service-learning design program (engaging first-year students, sophomores, juniors and seniors) with a first-year learning community to provide students with the benefits of an authentic design experience as well as the support of a first-year learning community. The learning community courses are used as an alternative path to the traditional first-year engineering program of the university.

Purdue University's First-Year Engineering Program

All engineering students at Purdue University are required to complete a common first year core of classes shown in Table 1 before matriculating to their respective engineering major. Minimum grade levels are established for matriculation to the major of their choice. The First-Year Program involves faculty, staff and academic advisors dedicated to first-year engineering students. There are two required engineering courses, Introductory Engineering I and II or *the Honors version of Engineering Design I and II which are shown in bold in Table 1. The emphasis of the first engineering course is design and the emphasis on the second semester is computing skills and tools, although the content is integrated between the semesters. All first-year students take the same first-year courses and are part of a common first-year program. They select their major in engineering after completing these core first-year courses.

Table 1: First-Year Engineering Required Courses

Required courses
Calculus I
Calculus II
General Chemistry I
Introductory Engineering I *or* *Honors Engineering Design I
Introductory Engineering II *or* *Honors Engineering Design II
English Composition
First-Year General Education Elective (Fundamentals of Speech Communication strongly recommended)
Physics I (mechanics)
Science Selective - Options include General Chemistry II, Computer Programming or Biology:

First-Year Learning Communities

The university has an extensive offering of learning communities across campus and engineering has been a major participant in this initiative. Each learning community consists of a series of linked classes where cohorts of students are registered together and participate in co-curricular activities during their semester or year together. Some learning communities also offered a residential component where students are assigned to the same floor of a residence hall. Students elect to participate in a learning community after they are admitted to the university. Information about the learning communities is distributed with admission notices. Students apply for the learning communities and indicate their preferences for all they are interested in through a website. A central staff that supports the learning communities places students into the communities. More than half of entering first-year engineering students participate in a learning community and there is traditionally a waiting list for placement as demand has continued to exceed capacity.

Service-learning has been integrated as a curricular or co-curricular connection for several of the learning communities[10]. Historically, these were self-contained projects within the first-year program. Limitations on the scope of these projects include the capabilities of the first-year students and the short duration of the academic period. While these efforts were being undertaken, a large service-learning design program was developed that involved students from all four years, first-year to senior. There were opportunities to link the first-year experience with the larger program through the learning community.

EPICS Program

EPICS is an engineering-centered, multidisciplinary, service-learning design program where students earn academic credit for partnering with not-for-profit organizations to develop and deliver designs to meet community needs.[11] The program began at Purdue University in 1995 with 40 students and has substantially grown since its inception. In 2012-13, 819 students were engaged in over 80 projects distributed across 31 sections. The program is explicitly multidisciplinary with over 70 majors participating, and it encompasses students from their first-year to senior year. The curricular structure is designed to allow students to participate over multiple semesters and supports long-term, reciprocal community partnerships. The long-term student participation allows projects to be developed over multiple semesters or years and allows projects to address complex and compelling needs.

EPICS teams, or course sections, consist of 8-24 students and are student led with a faculty or industry mentor (called an advisor), and a graduate teaching assistant (TA). Each team comprises multiple sub-teams, each one of which supports a single design project. The project timelines are completely decoupled from the semester schedule allowing projects to span multiple semesters or even years allowing projects of significant scope to be developed. Once a project is delivered, a new project is then identified by students under the guidance of their faculty mentor(s) and community partner(s).

Student assessment data indicates that students who are involved in EPICS early in their academic careers, report increase motivation to remain in engineering. The challenge of engaging students as early as their first year is that students can become overwhelmed. While the experience can be very positive, when students are adjusting to college life and course loads, the additional variable of an experiential learning environment can be foreign and sometimes overwhelming. In addition, while the vertical integration allows mentoring of younger students, older students do not always embrace the mentoring roles. The results have been bimodal with first-year students in the program having either very positive or negative experiences. To increase the number of first-year students and to insure a positive experience, scaffolding and support are needed through their experience. This was the motivation of adding the support of the learning community into EPICS.

Example EPICS Projects involving first-year students

The EPICS program currently has approximately 80 active projects. Projects generally fall into four areas of impact: Education and Outreach, Access and Abilities, Human Services and the Environment. These projects all involved first-year students along with older students. A few examples are provided below, but a complete list of projects can be access at http://www.purdue.edu/epics.

Braille Reader: The goal of the project is to design and build a multi-line, refreshable braille display to be used as a Braille eReader. The eReader would provide people who are blind or have visual impairments the capability to read multiple lines of Braille at a time, allowing them greater access to reading materials. Current devices capture the text on a screen and then display it in braille on the device but users can typically only read four to five words before having to refresh their device. Commercially available, single-line devices can cost between five thousand and fifteen thousand dollars, making them economically unattainable for many. The project seeks to provide an affordable and accessible reading system.

Prosthetic Finger: The goal of the project is to design a finger-like prosthetic device for a local person who lost seven fingers in surgery to allow her to sew. The basic concept is an index finger so that she is able to sew by holding a needle between her thumb and the prosthetic extension to her proximal finger. Initial prototypes were created using 3D printing and evaluated by the partner for use. The design was modified and at the conclusion of the fall semester, the final design was delivered allowing her to begin sewing again.

City of Lafayette Building Project: The goal of the project is to partner with the city of Lafayette, Indiana to analyze and improve the energy performance of a city office annex built in 2009. The building was designed to attain LEED Silver certification but was not actually awarded certification. The team is investigating the causes of failing to attain the certification and is working with the city engineers to develop a plan to attain that LEED Silver certification.

Otter Feeder for local zoo: The goal of the otter feeder is to provide a means for otters in the local zoo to be provided with fish in their pool without the involvement of zoo staff. The intent is to provide entertainment and enrichment for the otters as well as entertainment for the patrons of the zoo. The team worked through prototypes that could hold fish and release them. The project is near completion and involves two tanks of live fish that will release them at times set by the zoo staff into a tube that leads to the otter pool. The tanks are encased in a man-made rock in order to make the device look more natural and blend in with the rest of the exhibit. The project is expected to be delivered in Spring 2014.

Purdue University Wastewater: The goal of the project is to find more efficient means for the university to treat its wastewater. The large Midwestern university has a wastewater treatment facility but is seeking alternatives for a new design. This team is working with the university as part of the preliminary design work exploring alternatives for the future improvement. The result of the work will be a report to the university physical facilities office.

Haitian Central Plateau Home Designs: The goal of the project is to develop alternative house designs that can be used by the partner, Habitat for Humanity International (HFHI), in the central plateau region of Haiti. The homes were designed to be resistant to natural disasters, including floods, landslides, earthquakes, and hurricanes. The team has worked with HFHI to develop an earthbag house design and a system for repairing existing homes that have been damaged.

Integration of EPICS and Learning Communities

The benefits of the learning community and the EPICS offered the opportunity to combine the experiences into an alternative first-year experience. There have been two iterations of the experience. The first took the traditional course sequence and added the EPICS course to form a learning community. The second created a new course sequence and used EPICS as part of their first-year requirements.

First Iteration: Fitting within Traditional Sequence

Initially the existing first-year engineering course sequence was used as part of the learning community. Students participating in the learning community registered for EPICS in addition to the first-year courses. The learning community was designed like most on campus as a one semester experience including three linked classes: the first engineering course, either English or Communication and the EPICS course. Students were placed into these three courses as part of the learning community selection process by the central university learning community staff. The number of students totaled 96 which was determined by the number that could fit into two sections of English (20 each) and Communication (28 each). English and Communication are part of the first-year sequence. All students were enrolled in a common section of Introductory Engineering I so they could be together as a cohort. They were distributed among the 31 divisions of EPICS in groups of 3-5 on teams which included sophomores, juniors, and seniors. They were given the option to live on the same floors in the residence halls with separate floors for the men and women. About 75% of the students chose to live together.

Table 2: First Iteration of EPICS Learning Community

	Traditional First-Year Sequence	First-Iteration EPICS LC
Standard Core	Intro to Engineering	Intro to Engineering – Dedicated section with only LC students but follows traditional content
Learning Community Sequence	English, Communication or other general education course	Either English or Communications – Dedicated sections for the LC
		EPICS – additional elective course

This approach gave students several different "communities". Students were together in the larger community of 96 in the introduction to engineering course. They also had the community of the residence hall floors. The English and Communication courses offered four smaller communities of just the LC students. Another small community was their EPICS section that had 8-20 students and included students from outside the learning community. Co-curricular activities were sponsored by the learning community and led by the instructional staff during the fall semester.

This version of the learning community had many benefits as it engaged students in real engineering projects in their first semester and built a sense of community. Students enjoyed EPICS and many wanted to take the course in the second semester but many students did not have room in their schedules. This resulted in frustrated students as reported by the academic advisors.

There were also challenges linking the courses and content. The traditional courses teach a design process and EPICS teaches a slightly different design process. While the processes can be mapped into each other as demonstrated by the instructional team, students perceived them as different. The traditional courses also use Modeling Eliciting Activities (MEA) as a way to simulate authentic users for the large number of students in the first-year engineering program. These are useful learning activities when real users of designs are not available but all of the projects in EPICS have real users as community partners. Students viewed the MEA techniques as more burdensome than traditional sections that lacked authentic users.

Second Iteration: Year-Long Alternative First-Year Sequence

Instead of adding EPICS to an already full first-year load, an alternative sequence was created that used EPICS as a way to meet the design outcomes of the first-year. The traditional sequence includes two, two credit engineering courses. Since design is a common learning outcome of EPICS and the first-year engineering course sequence, all of the design learning would be accounted for in two semesters of the EPICS courses. A new course, "EPICS Learning Community Course", was created to cover the other outcomes that involved computing skills and awareness of the engineering disciplines. Some topics, such as ethics and teaming, were covered by the new course and EPICS. This redistributed the number of credits between the fall and the spring as seen in Table 3. In the first iteration of the LC, the fall credit loads were not problematic and the new sequence added some additional flexibility in the spring semester.

Table 3: First Year Sequence, Standard and Learning Community

	Fall Semester(credits)	Spring Semester (credits)
Standard Core	Introductory Engineering I (2)	Introductory Engineering II (2)
Learning Community Sequence	EPICS Learning Community Course (2) EPICS 101 (1)*	EPICS 101 (1)

Because the course was unique to the learning community, it could be customized to align with EPICS. Assignments were tailored to complement the learning community sequence. An example is that the reflection assignments in the new course built on the EPICS experiences. For example, critical and reflective thinking is an area assessed in EPICS but first-year students often struggle. To help them, a weekly reflection was included in the common engineering course on their EPICS experience. Feedback was provided and this helped their work in the EPICS course.

The common course also provided a means to address their experiences and introduce aspects of the EPICS experiences. For example, the assessments in EPICS are modelled after professional performance appraisals and require students to identify their most significant accomplishments and document them for evaluation. This method is often foreign to students but it was introduced and discussed in the first-year common course.

The learning community maintained the linkage with two English and two Communication courses as a third course. Another cohort was added that did not have either class. This brought the total number of students up to 120, which is the standard size for the first-year courses and allowed the LC to fill one section. It also allowed students who brought in credit for English and Communication to participate. There were also a few students who could not co-schedule three courses and the option of just the two linked classes added flexibility for them.

Results

Course evaluations and surveys for the second iteration showed that students had a positive experience. One of the most compelling is when asked if students would recommend others take the alternative path of the learning community or take the traditional first-year course sequence, no one thought they would prefer the traditional track, as seen in Figure 1. It is worth noting that there were numerous comments in the course evaluations that indicated that the students believed that the learning community sequence was a harder path. They commented that it seemed like more work, doing the designs in one course and the computing skills in another. The responses noted the additional work but still rated the experience high for their learning and overall experience. The EPICS learning community won the 2013 university Learning Community Advocate Award which is given for outstanding learning community experiences based on student evaluations.

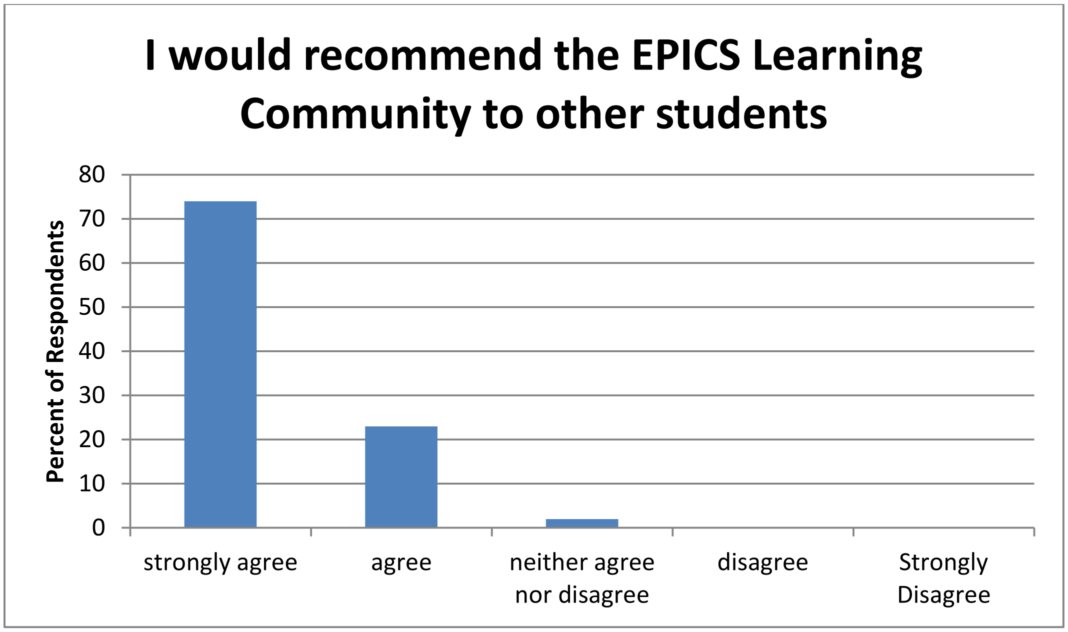

Figure 1: Students recommend the EPICS Learning Community to other students (second iteration of the learning community)

Students were asked if the first-year experience increased their interest in engineering seen in Figure 2. The results showed a strong positive impact and no decrease interest in engineering. For the first cohort of the second iteration, 87% remained in engineering after two years and 93% remained at Purdue University.

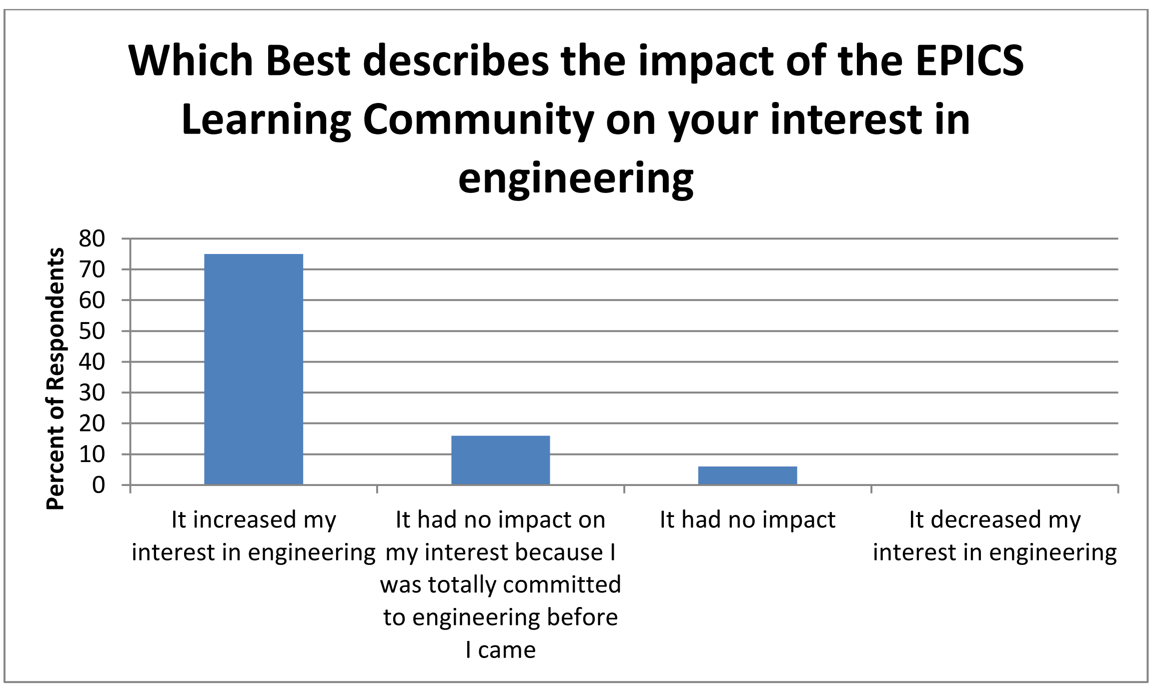

Figure 2: Impact on Interest in Engineering

Students were asked if their experience in EPICS helped them understand engineering as seen in Figure 3. Several comments reflected on the built-in mentoring of the EPICS classes. The opportunity to talk with upper division students was cited as a benefit as they sorted out their future major. An example was the [team focused on sustainability of communities]. Two seniors mentored 6 younger students including four from the learning community. The seniors provided leadership not only on the projects but also helped the students see what the rest of their engineering experience would be like. They offered guidance on major selection and also encouraged them through the challenges of the first-year. Students enjoyed talking with those who had made it through the first year.

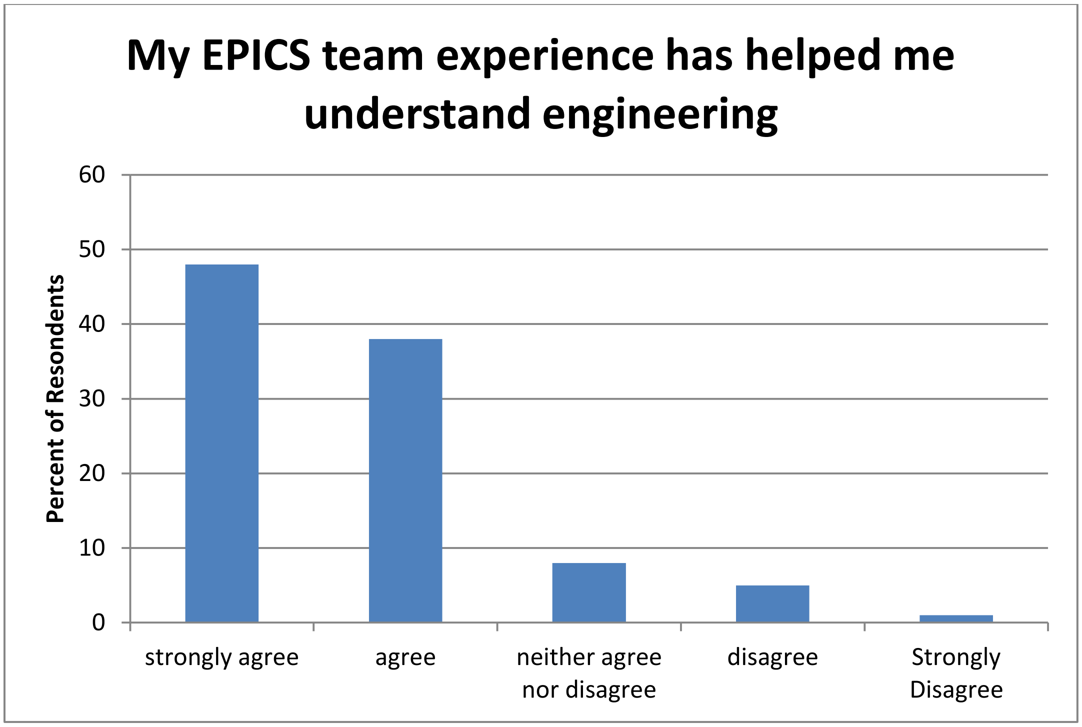

Figure 3: Understanding Engineering

Learning Outcomes were an important part of the experience and assessment data showed that the learning was at least comparable to the traditional sequence. For the computing tools and statistics topics, traditional exams were used and modeled after the traditional courses. Teaching assistants and instructors from the traditional sequences reviewed the exams for consistency. The exam average was on the higher end of the ranges for the traditional courses. Common questions were not used as the timing of the exams did not exactly align.

The design outcomes were assessed through a design task that was developed to assess human-centered design.[12] Both the EPICS and the traditional course sequence class use a human-centered approach to design. The emphasis of the first of the two traditional courses is design. At the end of the first semester, the design task was given to both the traditional class (FYE-NON) and the EPICS students (FYE-SL). The results showed a higher average level of proficiency among the learning community than the traditional class (see Table 4 and Figure 4). More students showed an understanding of including users through the design process, as measured by the number of students scoring a 4, 5, 6 or 7 on the task (scores of 1, 2, 3 suggest a less-comprehensive understanding of including users throughout the design process, where students with a score of 1 employ a “technology-centered” design process with virtually no inclusion of users; a score of 7 is the highest possible score on the task).

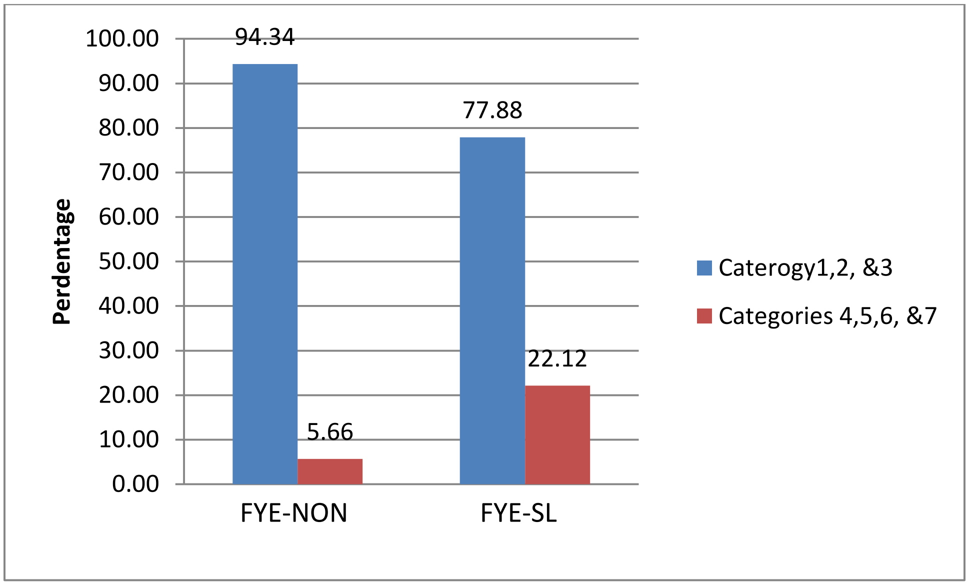

Figure 4. Percentage of students in FYE-NON and FYE-SL who addressed users’ needs in the design process versus (Category 4, 5, 6 &7) those who did not (Category 1, 2, &3)

The difference between the traditional students (FYE-NON) and the students participating in EPICS (FYE-SL) was examined statistically. A Pearson Chi-square tests for independence were used to determine if the two groups of students addressed users’ needs differently when completing the design task. Yate’s correction for continuity was used to compensate for the overestimate of the Chi-square value. Chi-square tests for independence with Yate’s correction indicated significant association between whether users’ needs are taking into account when completing the design versus and whether students were engaged in service-learning experience (X2(1,n=210)= 10.60, p< 0.05, phi= 0.24), see Table 4, Figure 4. The value of phi indicated a small to medium effect size. Students with service learning experience are more likely to incorporate users’ needs into their design process compared to students who did not have the service learning experience.

Table 4. Number and percentage of students within the service learning class (FYE-SL) versus the more traditional introductory engineering design course (FYE-NON).

	FYE-SL(n=104)		FYE-NON (n=106)	
Users' needs not considered throughout the process(Caterogy1,2, &3)	n=82	77.88%	n=100	94.34%
Users' needs considered throughout the process(Categories 4,5,6, &7)	n=23	22.12%	n=6	5.66%

Finally, one of the interesting positive results of the learning community arose from negative comments in the course evaluations of EPICS. A small number of first-year students who are not part of the Learning Community take EPICS. These students reported that the learning community students gave them an advantage of all the support they got through their common course and the connections to EPICS. This was an indication that the connections worked and it also raised ideas for supporting the other students new to EPICS.

Conclusion

The experience has been very positive. Allowing the EPICS track to substitute for the first-year track allowed for the learning community to extend for an entire year which added to the student experience. The combination of courses offered the kind of support the students needed to adapt successfully to the rigors of the university and the service-learning design program. The addition of the first-year students to the EPICS Program added energy to the teams but also put strain on the program. A balance of juniors/seniors is needed to mentor the first-year students and to guide the projects through technical hurdles. While these mentoring experiences are valuable for all, it also requires a sufficient number of mentors and we are addressing how to attract more upper division students before any expansion of first-year students is possible.

The combination of the small, vertically integrated teams and the support for the learning community was a positive. There were clearly times when the first-year students needed their own community. The common course allowed us to customize experiences that would scaffold their learning and experience in EPICS. The vertically-integrated and multidisciplinary teams of EPICS provided an experience that bolstered their design to be in engineering and provided them with valuable skills. Work has to be done with the older students to equip them to be mentors and also to help them understand how valuable that experience is. Some of the older students view the younger students as burdens and this can negatively impact recruitment upper division students an elective course such as EPICS. For a program like EPICS to work most effectively, there needs to be a critical mass of upper division students with disciplinary and technical skills. Too many first-year students restricts the scope of projects that can be done. This limits the capacity of the program to expand first-year participation by how fast it can attract more upper division students.

Future work will include understanding the impact of the early experience and tracking the retention of the students who participate in the learning community. Early indications show higher retention but this will be tracked over multiple years and cohorts.

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