Evaluating the impacts of community service on student learning outcomes

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Evaluating the impacts of project-based service learning on students through the EPICS program

Abstract

Project-based service learning (PBSL) is an innovative approach to education that is being increasingly adopted by many engineering programs. Yet while PBSL itself is becoming more prevalent, the body of research behind service learning is lacking in some areas. Previous research has identified a wide range of positive outcomes that have been attributed to service learning including increased social responsibility, teamwork skills, communication skills, critical thinking skills, understanding of societal context, and many more. However, this research is composed primarily of self-reported evaluation studies of specific programs and anecdotal descriptions which limit the ability to fully evaluate service learning impacts. While these methods have provided valuable information, there is a need for quantitative research that defines the relationship between PBSL experiences and student outcomes. Previous research has identified the need for standardized instruments to accomplish this. Furthermore, multi-institutional research has been recognized as a valuable way to investigate and analyze the impact of PBSL on students.

The Engineering Projects in Community Service (EPICS) program is a service learning program that integrates engineering design with the needs of the local community through a multi-disciplinary, vertically-integrated curricular structure. The studies presented in this report include assessment of the EPICS programs at two universities, Purdue University and the South Dakota School of Mines and Technology (SD Mines). The assessments evaluate 1) the impacts on critical thinking skills as measured by the Critical Thinking Assessment Test (CAT); 2) the impacts on intercultural competence as measured by the Intercultural Development Inventory (IDI); and 3) the impacts on student perceptions and attitudes as measured by focus groups. To examine the impact, the results of students who are enrolled in the EPICS courses were compared to matched samples of students in other courses to determine whether the results can be attributed to service learning. The intent of this paper is to describe the process by which the student outcomes were evaluated, present results, and to discuss how this knowledge can be used in both the improvement of existing programs and development of new service-learning programs.

The results of the study indicate that while, statistically, students' IDI scores showed no increase from first year to final year in an engineering program, when engaged in the EPICS service learning program, students' IDI scores increased (at an alpha of 0.05) with participation in service learning. Further, while students' CAT scores were statistically higher (alpha 0.05) as freshman than as seniors, their critical thinking skills, as measured by CAT, were statistically higher as exiting seniors after participation in EPICS. Overall, these indicators of student learning outcomes indicate a high potential for improvement with participation in service learning, as opposed to without.

Introduction

There have been numerous calls over the past few decades over the need to improve undergraduate engineering education in order to meet the increasingly complex, interconnected, global and societal challenges, such as sustainability, facing engineers of the future. The importance of educational strategies that not only train students with the necessary technical skills, but prepare students for the global workforce through the development of professional skills has been addressed in reports such as: The Engineer of 2020[1], Educating the Engineer of 2020[2], the Civil Engineering Body of Knowledge[3], and Environmental Engineering for the 21st Century: Addressing Grand Challenges[4]. Some of these professional skills include: engaging collaboratively with stakeholders, transforming education to improve students' communication and critical thinking skills, the ability to work in multidisciplinary and multicultural teams, and the increased awareness of social and cultural contexts.

Project-based service learning has been identified as an innovative approach to improving student learning outcomes, including both technical and professional skill development. Various programs throughout the United States, and globally, have implemented successful service learning programs, both through co-curricular (Engineers Without Borders, EWB, is one example) and curricular structures. One example of a pedagogical approach to project-based service learning is the Engineering Projects in Community Service (EPICS) program, started at Purdue University in 1995. Since then, the Purdue EPICS program has expanded to include over 130 projects with 57 community partners, engaging 1200 students in the 2018-2019 academic year alone[5]. The EPICS University Consortium includes programs at over 30 universities worldwide.

The principles of EPICS programs are to engage students in long-term partnerships with local, regional and global community partners as they learn design while developing solutions that are delivered to their partners [7]. At both institutions in this student, design teams are 3-6 students and involved undergraduate students from different engineering disciplines as well as other majors outside of engineering. The structure of the programs differed in the number of design teams that were part of course divisions or sections and how many were mentored by a specific faculty member. Students were allowed to participate over multiple semesters on projects that spanned semester as both institutions. Students were placed in leadership roles and had responsibilities for the project development as well as the community partnerships. Reflection was a key part of both programs as a learning enhancement and assessment method.

An example project was the design of a greenhouse and educational center with a tribal partner. The reservation where the tribe lives is classified as a food desert and access to fresh fruits and vegetables is very limited. To address this need, the students teamed with the tribal college faculty and students to design a greenhouse that could be used to produce food while teaching students and tribal members how they can grow food themselves with a focus on traditional foods and medicines. The teams focused on the cultural importance of native plants for food, medicines and cultural significance. The experience included students visiting the reservation to learn more about the physical space, the tribe and their culture. Three grants were written by the teams to fund the project for the construction of the greenhouse and to furnish the facility to meet the intended purpose.

Engagement in an EPICS program has been demonstrated to improve student professional outcomes, including skills such as the ability to work on a team, resourcefulness, awareness of the community, and communication skills[6, 7]; however, these results were measured through student self-responses. Formalized, quantitative assessments of the impacts of service learning on students' professional development skills, such as critical thinking[8, 9] and intercultural competence are still needed. This paper presents the results and analysis of quantitative measurements of student outcomes, including critical thinking and intercultural competency, from two institutions with EPICS programs, Purdue University and South Dakota School of Mines and Technology (SD Mines), collected from students both in EPICS programs and not in EPICS programs in order to assess the influence of participation in service learning on students.

Critical Thinking

Critical thinking has been both directly and indirectly identified as a critically important student learning outcome, as it is perceived to relate to the ability to solve the types of broad, complex societal problems currently faced by the emerging engineering workforce. However, it remains a somewhat elusive and difficult to measure skill[9]. The Critical Thinking Assessment Test (CAT) is a skills-based, inclusive, validated test that was developed by researchers at Tennessee Tech and funded by the National Science Foundation that measures performance on critical thinking skills. The test was developed to assess twelve skills that were identified by faculty as important skills for critical thinking[8, 10] using a short answer essay format. Literature indicates that research supports the reliability, validity, and non-cultural biases of the CAT instrument as an effective means to quantitatively measure students' critical thinking skills[10].

Intercultural Competence

The IDI utilizes the intercultural development continuum that is a model of intercultural competence based on the Developmental Model of Intercultural Sensitivity (DMIS) originally proposed by Bennett [11]. IDI research has since reinforced the basic principles of the DMIS while also providing further revision to some aspects of its framework[12, 13]. The intercultural development continuum, shown in Figure 1, represents these revisions and is the scale used by IDI to evaluate intercultural competence. The continuum ranges from a more monocultural mindset, at the stages of denial and polarization, to a more intercultural or global mindset, at stages of acceptance and adaptation. Individuals who have a more intercultural mindset have a greater capability for responding to cultural differences and commonalities. IDI scores can be related to the continuum based on the scale shown in Figure 1. As seen on the scale, higher scores correlate to greater intercultural capabilities.

The IDI test measures both the subject's perception of their intercultural competence, or perceived orientation (PO), and the subject's actual intercultural competence, or developmental orientation (DO).

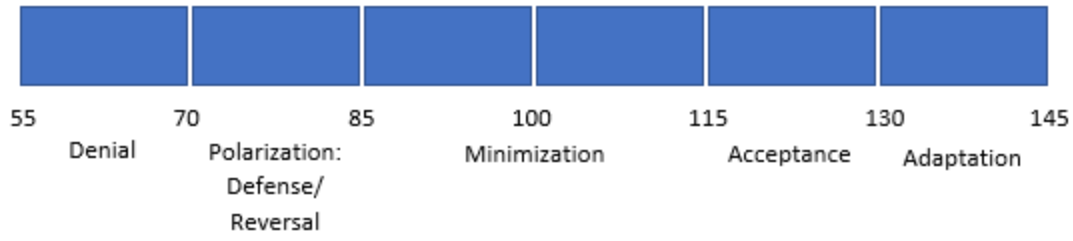

Figure 1. Depiction of IDI scoring scale as used in IDI Individual Profile Results[13]

Methods

In this investigation, students from two universities with EPICS programs, one well-established program at Purdue University and one new EPICS program at SD Mines, were recruited to participate in assessments of critical thinking and intercultural competency. First year students participating in EPICS programs and students participating in EPICS programs for three or more semesters were assessed along with students in various first year and senior engineering courses who were not participating in EPICS (non-EPICS) from the two universities were assessed. Non-EPICS participants were selected by seeking courses with professors that were willing to provide the assessments as a part of the course. This provided an incentive for students outside of the EPICS program to complete the assessments. The assessments were a requirement of the course for the students at the university with the newer EPICS program, while EPICS students from the established program were given the option to participate and those that elected to participate received a professional development hour credit as incentive to participate.

The assessments were accomplished by assigning each student a 7-digit code to use in place of their names to protect their identity and responses per the Institutional Review Board (IRB) approval. This code was then emailed along with consent forms and instructions to each individual student by an external entity, so that the research team cannot correlate individual names with codes. Furthermore, even though students were required to complete the assessments as a requirement of the course, the students were still given the option to consent to their results being included in the database. The consent form had an implied-consent format that required the student to sign and return the document only if they do not want to be included in the research database.

The assessment instruments used included a demographic survey, the CAT, and the IDI. The demographic survey included questions that identify the class level and the numbers of semesters the student has participated in EPICS, along with other demographic information. The purpose of this information was to categorize the CAT and IDI results belonging to EPICS, non-EPICS, first year or senior students. Table 1 summarizes the assessment data collected. Because the CAT involves significant faculty and researcher time in scoring and is more expensive than other tests, a smaller total number of CAT tests were administered. A non-scored placebo with similar short essay types of questions was administered randomly to students who were not sent the CAT test in order to achieve a similar time and effort level for all participating students.

Table 1. Summary of the numbers of assessment tests collected.

	CAT		IDI	
Student category	Purdue	SD Mines	Purdue	SD Mines
Non- EPICS First Year Students	19	30	-	47
Non-EPICS Upperclassmen	-	31	-	61
EPICS First Year Students (1-2 semesters)	30	-	21	16
EPICS Upperclassmen (3+ semesters)	23	25	31	14

In order to assess the influence of the service learning program on other indicators of student professional development, as part of the project investigations, focus groups were also held with EPICS students at SD Mines from 2017-2019 in order to measure the influences of EPICS participation on other students' perceptions of: stakeholder involvement in the design process, attitudes towards engineering design, sustainable design, multi-disciplinary design, and culture and diversity. In order to support continuous course improvement, focus groups and Small Group Instructional Diagnosis (SGID) each year during the project period.

For focus groups, two dates were offered for each core group (new and returning EPICS students) in an attempt to keep the group number down to a manageable size and to maximize availability for interested students. All participants signed a focus group consent form. With the exception of the 2019 focus group, all sessions were recorded in order to analyze and tabulate key word discussions.

Results and Discussion

Critical Thinking

Analyses of the CAT were performed using either the independent Student's t-test or the independent t-test with unequal variances, depending on the results of F-tests for sample variances, with an alpha of 0.05 for each comparative data set. The analyses indicated, first, that there was no significant difference between the CAT scores of students at the two universities for all subcategories (first year, upper level, EPICS, non-EPICS) (n = 86 for SD Mines and n= 76 for Purdue), therefore allowing multi-institutional studies to draw further conclusions about the influence of service learning on students' critical thinking skills since there was no statistical difference between students' skills at either institution.

Since critical thinking skills are believed to be influenced by educational strategies, the grouped multi-institutional CAT scores for first year students were compared to the grouped CAT scores for senior students both participating in EPICS and non-EPICS students in order to evaluate the effectiveness of the service learning pedagogy on students' critical thinking skills. At an alpha of 0.05, it was found that students in the first-year engineering programs (n=79) demonstrated statistically higher critical thinking skills than students in the senior year of engineering programs (n=31). This is unexpected. Research has shown that students increase their critical

thinking skills during college [14], although some have questioned if the trend has been declining [15]. The senior cohort is taken from one institution (SD Mines) and from two disciplines. The first-year students include students who have volunteered for alternate first-year programs (Purdue) and may have introduced a sampling bias. When students who had participated in EPICS for 3 or more semesters were sampled (n=48), they exhibited scores statistically significantly higher than either of the other two comparison cohorts as seen in Figure 2.

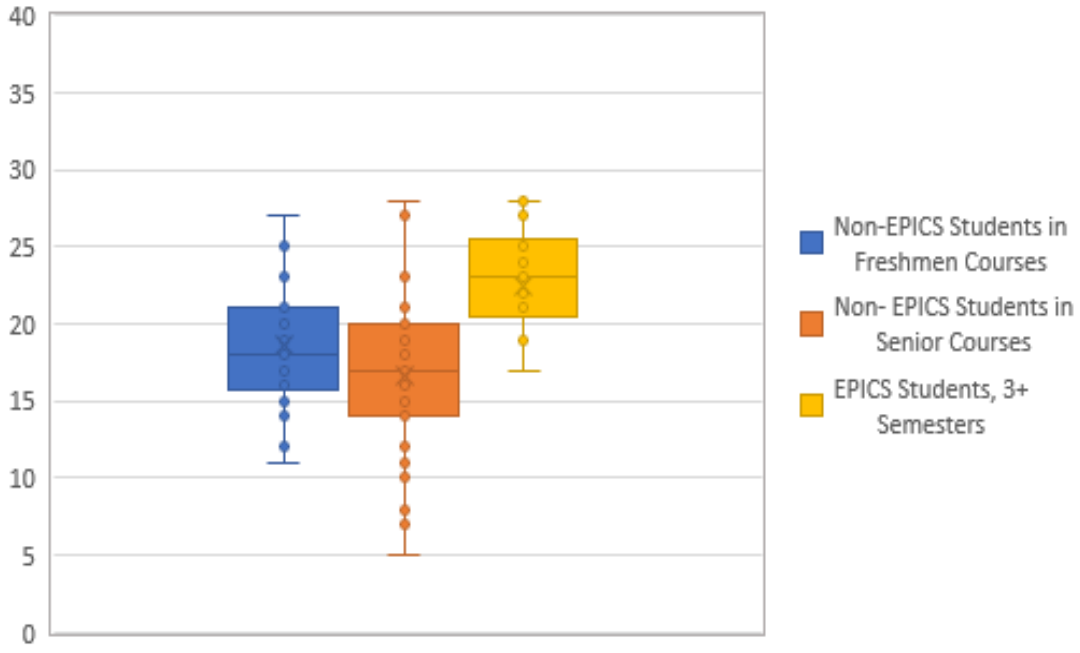

Figure 2. Critical Thinking Scores as Assessed by the CAT.

While many studies have indicated that PBSL improves students' critical thinking skills, this is the first known quantitative validation of this concept[16]. The results indicating improvements in critical thinking skills for students engaging in service learning are consistent with findings in literature. Using the CAT, Gunay et al [17] measured the impacts of a semester-long project based learning pedagogy in software development on students' critical thinking skills and found an 11% increase in critical thinking skills from pre- and post-semester assessments. Ahern et al [9] conducted a literature review of critical thinking in engineering education and concluded that there is a need for interventions and methodologies that are imbedded throughout undergraduate programs, with linkages and relationships emphasized throughout various stages of education. Because the EPICS framework facilitates multi-semester and vertical integration of student engagement in service learning, it fosters this type of imbedding.

Intercultural Competence

Analysis of IDI results, particularly the developmental orientation, was completed as shown in Figure 3. The developmental orientation indicates one's primary orientation toward cultural differences and commonalities along the continuum as assessed by the IDI. The developmental orientation is the perspective one would most likely use in situations where cultural differences and commonalities need to be bridged[13]. Analyses of the IDI were performed similarly to the methods used for analyses of the CAT, using either the Student's t-test or the t-test with unequal

variances, depending on the results of F-tests for sample variances, with an alpha of 0.05 for each comparative data set.

Analyses indicated that there was no significant difference between IDI scores of students at the two participating institutions at alpha of 0.05, which validated the use of scores from both institutions together in further analyses (n=52 and n=30). Further analyses were conducted in order to assess the effects of the PBSL pedagogy on students' intercultural competency using grouped, multi-institutional and vertically-integrated scores, since traditionally educated students were demonstrated to have no statistical improvements in intercultural competency through their education. Students' IDI scores showed no increase from first year (n=47) to final year (n=51) in an engineering program, indicating that traditional engineering has no influence on improving students' intercultural competency. However, when engaged in the EPICS service learning program, students' IDI scores (n=108) increased with participation in 3 or more semesters of EPICS service learning courses (n=82).

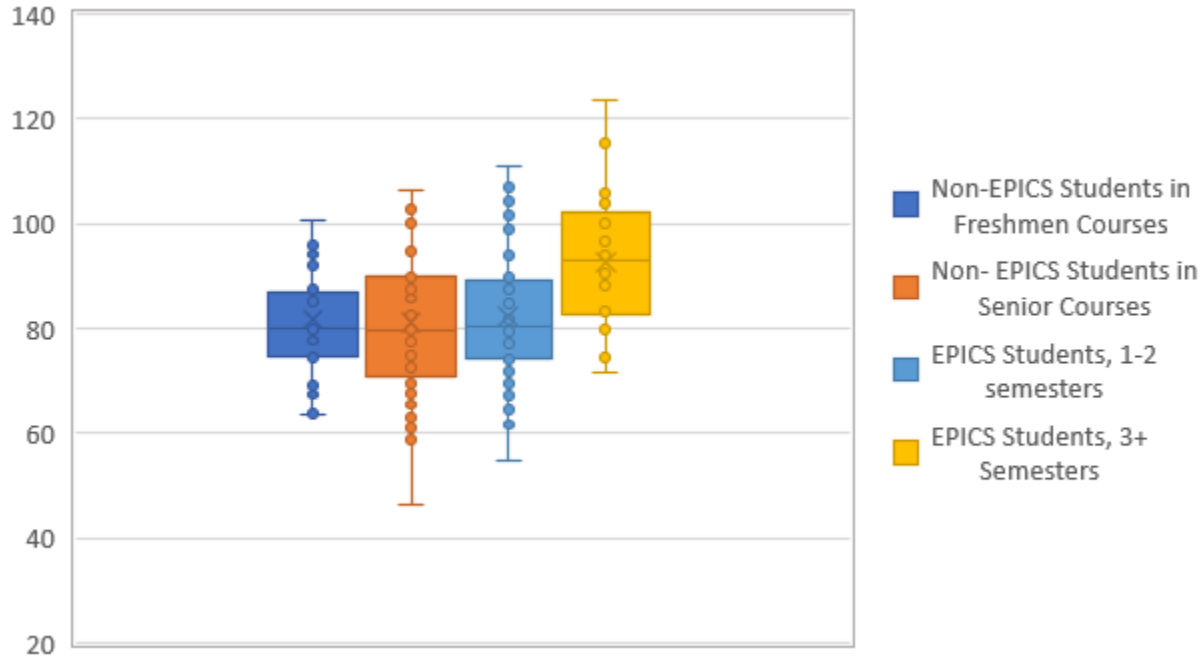

Figure 3. Developmental Orientation Scores as Assessed by the IDI

It is noted that while the results indicate that intercultural competency is improved through participation in PBSL through EPICS, these investigations cannot distinguish the effects of the pedagogy from a potential inherent inclination for students who already have higher intercultural competence to participate in PBSL Jesiek et al [18] applied the Miville-Guzman Unviersality-Diversity Scale to assess the intercultural competency of students opting into global engineering programs and found that the levels of cross-cultural competency for students opting-in were significantly higher than those not opting-in. Further, their investigations indicated that participation in immersive global research experiences significantly improved students' cross-cultural competency. Similar results are reported by Bielefeldt et al [16].

Other Student Professional Development Measures

The results of the focus groups (shown in Figure 4) indicated that students' participation in EPICS at SD Mines showed significant improvements in students' attitudes and perceptions of stakeholder involvement in the design process, attitudes towards engineering design, sustainable design, multi-disciplinary design, and culture and diversity.

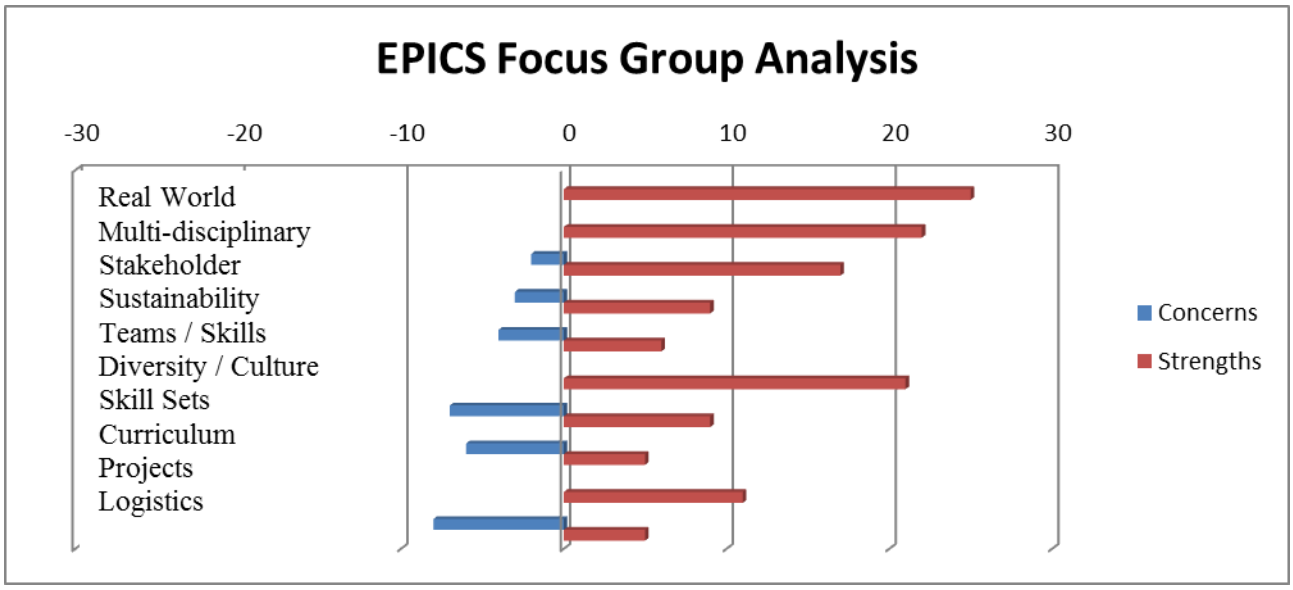

Figure 4. Analysis of Focus Group Sessions for EPICS (2017-2019)

These results are similar to reports in literature, which indicate that EPICS and PBSL participation have positive influences on numerous additional measures of professional development outcomes[6, 7, 16].

Both of the EPICS Programs meet the core attributes described for EPICS programs. While each manages the teams slightly differently to meet their respective faculty teaching load models, the core students service learning experience is very similar and makes it likely that the findings in this study would be evident on other campuses with EPICS programs.

Acknowledgement

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