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Impact of Service Learning on Engineering Student Development*

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Traditional engineering curriculum can be enhanced by incorporating project-based service learning opportunities. One example of a pedagogical approach to this is the EPICS program, founded at Purdue University. Students at two universities with EPICS programs were quantitatively assessed for the program's impacts on critical thinking and intercultural competency, and the cognitive diversity implications and professional development outcomes were examined. Instruments for assessing these attributes include the Critical-thinking Assessment Test, Intercultural Development Inventory test, Hermann Brain Dominance Instrument, and focus groups, respectively. Improvements in critical thinking and intercultural competency were observed for students involved in EPICS for more than three semesters compared to both a first year and senior cohort not participating in the program. EPICS also engaged students with more diverse thinking preferences compared to a set of students engaged only in a traditional engineering curriculum. Professional development outcomes were also improved through involvement in the EPICS program. These studies indicate that there are clear benefits to students through their involvement in project-based service learning with the EPICS program, as well as to universities, by offering opportunities to engage and retain students with cognitively diverse problem-solving approaches.

Keywords: service learning; critical thinking; intercultural competency; cognitive diversity

1. Introduction

To embrace the concept of personalized learning posed by the NAE Grand Challenges [1] and develop the creativity and innovation skills that employers are seeking [2], traditional engineering curriculum must adapt to provide more effective learning experiences, such as problem-based service learning (PBSL). A fundamental premise of the NAE Grand Challenge on personalized learning is that students understand and approach problems differently. This same fundamental precept is held by Felder and Brent in their landmark article, "Understanding Student Differences" [3] and by Ned Herrmann on developing the creative brain [4]. To this end, service learning can satisfy multiple learning styles [5] and engage students with diverse thinking preferences. Participating in service learning can also have a significant positive effect on outcomes such as academic performance (including critical thinking skills) and values (including promoting racial understanding) [6].

PBSL programs have increasingly been incorporated into university engineering curricula. These programs enable a student to receive academic credit while solving real-world community service issues. One example of a pedagogical approach to PBSL is the Engineering Projects in Community Service (EPICS) program started at Purdue University in 1995. Since its start, 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. The EPICS University Consortium includes programs at over 30 universities worldwide [7].

EPICS projects engage students in many facets of design through a vertically-integrated, multidisciplinary, and multi-year framework that has been shown to improve retention, design thinking and professional skills including teamwork and communication [8, 9]. However, the impact of this engineering-focused PBSL program has never been quantitatively assessed for its impact on critical thinking skills, intercultural competency, and retention of cognitively diverse students, all of which are necessary to develop engineers able to solve society's increasingly complex problems.

This paper presents the results and analysis of quantitative measurements of student outcomes, including critical thinking and intercultural competency, and examines the cognitive diversity implications for students though studies that include sampling students from two institutions with EPICS programs, Purdue University and South Dakota School of Mines and Technology (SD Mines). The data collected includes students both

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in EPICS programs and not in EPICS programs to assess the influence of participation in service learning on students.

2. Methods

2.1 Pedagogical Practice (EPICS)

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 [10]. At both institutions included in this study, South Dakota School of Mines and Technology and Purdue University, design teams included 3–6 students and involved undergraduate students from different engineering disciplines as well as other majors outside of engineering.

While the programs shared common goals and objectives, their structures differed slightly in their approach to faculty mentorship and the number of design teams that were part of course divisions. Students in both programs could participate over multiple semesters on projects that spanned over years at 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 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. 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. Table 1 provides examples of

Table 1. Examples of Purdue University EPICS projects and their project descriptions

Team Name	Description	Partners	Majors
Camp Riley	The mission is to design enhancements and assistive devices for the campers at the accessible outdoor camp, Camp Riley, located at Bradford Woods, Indiana	Camp Riley, Bradford Woods, CHAMP Camp	AcE, CE, CEM, EE, IE, ME, IE, HS, SLHS
Children's Educational Demonstrations (CED)	Our mission is to design and create interactive models that bring science to life for children visiting the Indianapolis Children's Museum	Indiana Children's Museum.	BME, Biology, Education, EE, CmpE, ME
Columbian Park Zoo (ZOO)	Design educational materials to be used by the Columbian Park Zoo located in Lafayette, Indiana.	Columbian Park Zoo	AS, ABE, CmpE, EDU, EE, IE, ME, CE
Database and Innovative Software for the Community (DISC)	The mission is Create data base applications and innovative solutions to help not for profit, educational and service agencies. Many of the current projects use .net and databases, but there are also python, HTML, CSS, and other technologies.	Day Break Rotary Club, Earl Park Public Library, Lafayette Crisis Center	CmpE, CS, CIT, COMM, EE, IE
Environmental Justice, Access, And Education (EJAE)	This team partners with nonprofits working in underserved communities to address needs related to environment and education. Active projects include	Overbrook Center in Philadelphia, PA, The Grand Caillou/Dulac Band of Biloxi-Chtimaca-Choctaw. EPICS High School in Washington, DC.	CE, IE, EEE, ES, ME, LA, MGMT, Education
Global Active Problem Solving (GAPS)	Developing alternative energy solutions to provide power to remote villages in rural areas. GAPS is currently working with a tribal partner in Brazil and an EPICS university partner in Colombia.	University of Norte, Barranquilla, Atlántico, Colombia, Kayapó community of A'Ukre, Brazil	CE, CmpE, EE, EEE, IE, ME, MGMT, LA, EDU, Physics, Spanish
Greater Lafayette Area Special Services (GLASS)	Develop technological solutions which enable students with disabilities aged 3-21 to function more independently and enjoy a better quality of life.	Greater Lafayette Area Special Services (GLASS)	CmpE, EE, IE, ME, MGMT, Special Ed, SLHS

Key: AcE = Acoustical Engineering; ABE = Agricultural and Biological Engineering; AS = Animal Science; BME = Biomedical Engineering; CE = Civil Engineering; COMM = Communications; CmpE = Computer Engineering; CS = Computer Science; CIT = Computer Information Technology; CEM = Construction Engineering Management; EDU = Education; EE = Electrical Engineering; EEE = Environmental and Ecological Engineering; ES = Environmental Science; HS = Health Science; IE = Industrial Engineering; LA = Liberal Arts; ME = Mechanical Engineering; MGMT = Management; Special Ed = Special Education; SLHS = Speech, Language, and Hearing Sciences.

projects. A full description of the Purdue teams can be found at https://engineering.purdue.edu/EPICS/Projects/Teams. For examples of teams at other EPICS Universities, see the EPICS University website at: https://engineering.purdue.edu/EPICS/teams

2.2 Measures of Critical Thinking

Critical thinking has been both directly and indirectly identified as an 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 skill to measure [11]. 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 [12, 13] 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 [12].

2.3 Measures of Intercultural Competency

The Intercultural Development Inventory (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 [14]. IDI research has since reinforced the basic principles of the DMIS while also providing further revision to some aspects of its framework [15, 16]. The intercultural development continuum 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. 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) [16].

2.4 Measures of Cognitive Diversity and Implications for Students

The Herrmann Brain Dominance Index (HBDI) typological model, shown in Fig. 1, has a substantial research base with over a million participants in the multiple regression model and has been tested

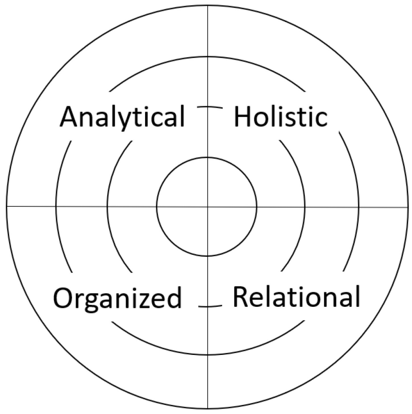


Fig. 1. Graphic depicting the four quadrants of the HBDI topological model [5, 13].

extensively for both reliability and validity [4]. Given these measures and the continued strong industry interest in effective team processes, the instrument is gaining in popularity as the industry instrument of choice [17]. Individuals with strong analytical abilities tend to dominate the upper left quadrant, individuals with a strong holistic thought processes tend to dominate the upper right quadrant, individuals that are highly organized tend to dominate the lower left quadrant, and those that are more relational in their thinking tend to dominate the lower right quadrant.

In an earlier study focused on building cognitive diversity in engineering students through curricular interventions [18], data was collected in 2012 in a traditional engineering curriculum at the South Dakota School of Mines and Technology for a required first year and senior year course.

While the data illustrated in Fig. 2 is only for one particular major, the results are consistent with literature [3, 4]. There are several observations that one can make from Fig. 2. The first is that engineering students are likely to be drawn to a more analytic curriculum, but not all. Indeed, from the first to the senior year, student thinking preferences tend to be more fully concentrated in the analytic quadrant. Since typology does not typically change over a four-year period, this indicates a loss of more diverse students. The second observation is that there are very few women that persist in an engineering curriculum (in this case, no women were in the senior engineering course). To be clear, women are intellectually capable of persisting in a robust engineering curriculum, but are less inclined to have an interest in doing so. The last observation is that very few students whose primary typology rests in the holistic (upper right quadrant), which tend to be related to entrepreneurship, tend to persist to the senior year. All of these have rather profound implications for student recruitment and

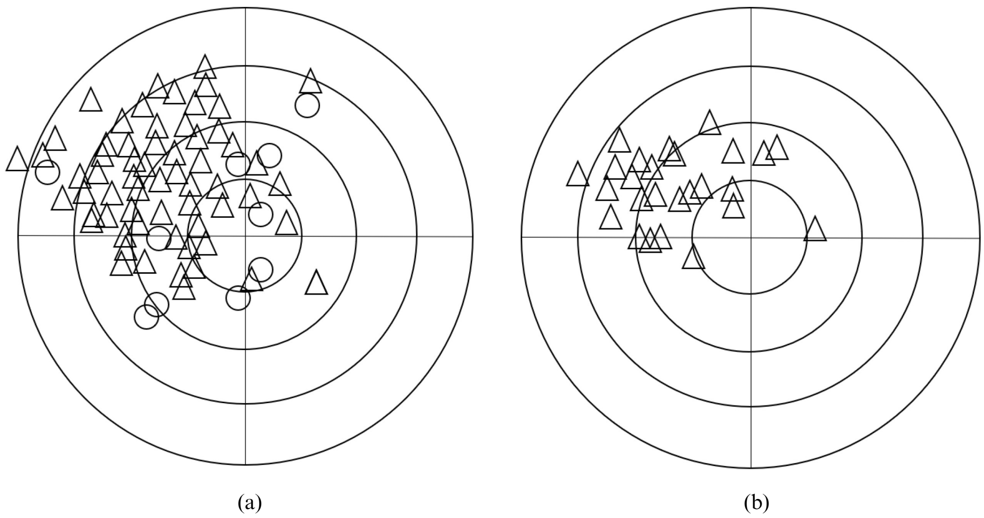


Fig. 2. Typological thinking aggregate profiles for (a) first year and (b) senior year course in a traditional engineering curriculum. Triangles indicate typologies for male engineering students and circles indicate typologies for female students [18].

retention in an engineering curriculum as well as for the diversity of the future workforce.

Karlin and Kellogg demonstrated that there is a difference between the average thinking styles of male and female engineering students [19]. Fig. 3 captures graduating student typologies in the Industrial Engineering program from the South Dakota School of Mines and Technology.

While Fig. 3 indicates greater cognitive diversity for both male and female students than that indicated in Fig. 2, it is also clear that the average typology for female students is shifted downward and to the right of their male counterparts. In their report, Kellogg and Karlin posit that the traditional engineering curriculum tends to focus on the analytical thinking style, which is in conflict with the thinking styles of many women and some men. Further, this typological mismatch may have a significant impact on student retention and persistence, perhaps more so than the advising process. This notion is reinforced by Felder and Brent [3] and is shown in practice in an analysis of SD Mines student retention data in 2012 which indicated no student left engineering due to poor advising. It's possible that retention of engineering students, particularly female engineering students, is more closely tied to thinking preference typologies than was previously thought. Thus, to improve engineering retention and student persistence, an engineering curriculum that is more cognitively diverse is

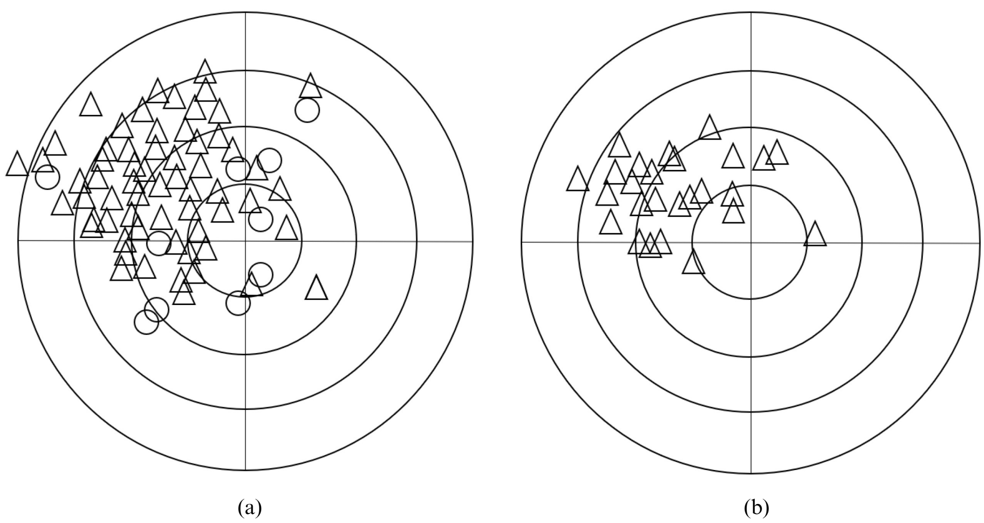


Fig. 3. Typological thinking aggregate profiles for (a) male and (b) female students in a cognitively diverse engineering curriculum. Triangles indicate typologies for male engineering students and circles indicate typologies for female students [19].

Table 2. Summary of the number of assessment tests collected

Student Category	CAT		IDI		HBDI	
	Purdue	SD Mines	Purdue	SD Mines	Purdue	SD Mines
Non-EPICS First Year Students	19	30	–	47	–	76
Non-EPICS Upperclassmen	–	31	–	61	–	56
EPICS First Year Students (1–2 semesters)	30	–	21	16	54	23
EPICS Upperclassmen (3+ semesters)	23	25	31	14	7	9

critical. Kellogg has shown that embracing cognitive diversity can be a more effective strategy for creating a more diverse campus environment [18]. Further, a more cognitively diverse curriculum would be required if a goal of an engineering program is to develop the team and innovation skills needed for the 21st century and meet the National Academy of Engineering's goal for the grand challenges [1, 2].

2.5 Data Collection

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, intercultural competency, and cognitive diversity. 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 did not participate in EPICS (non-EPICS) from the two universities. 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 could not correlate individual names with codes. Furthermore, even though students were required to complete the assessments for 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 did not want to be included in the research database.

The assessment instruments used included a demographic survey, CAT, IDI, and HBDI. 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 2 summarizes the assessment data collected for CAT, IDI, and HBDI. 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.

The Herrmann Brain Dominance Inventory was offered to all students who participated in EPICS at SD Mines along with select group of EPICS students at Purdue. In addition, non-EPICS students in select courses in Industrial Engineering and Engineering Management and in Civil and Environmental Engineering were included in instruments for non-EPICS students. Students involved in the Center for Advanced Manufacturing and Production (CAMP) extra-curricular programs at SD Mines were also invited to complete the HBDI instrument. A total of 39 CAMP students completed the instrument. Of these, 13 were also in EPICS; 27 were not in EPICS.

To assess the influence of the service learning program on other indicators of student professional development, focus groups were also held with EPICS students at SD Mines from 2017–2019. 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. To support continuous course improvement, additional focus groups and Small Group Instructional Diagnosis (SGID) were implemented each year during the project period. With the exception of the 2019 focus group, all sessions were recorded in order to analyze and tabulate key word discussions. A total of 26 EPICS students participated in 3 years of focus group sessions.

3. Results and Discussion

3.1 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 that there was no significant difference between the CAT scores of students at the two universities for all combined 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 upper-classmen EPICS students and senior non-EPICs 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 [20], although some have questioned if the trend has been declining [21]. One study indicated that divergent thinking, which is thought to relate to a students' ability to approach problems in new manners, remains stagnant with progression through engineering curricula [22]. Sola et al. [23] found that creativity decreases in students with progression in engineering, and Coleman et al. [24] found that students' perceived abilities in design thinking decreased from first year to senior year in a nation-wide study. It is not clear, however, if these indicators measured in literature are correlated to potential changes in students' critical thinking however. Further, in our studies, 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.

Our analyses indicated that when students who had participated in EPICS for 3 or more semesters were sampled (n = 48), they exhibited scores statistically significantly higher (alpha of 0.05) than both the first year student cohort and the senior non-EPICS student cohort, as seen in Fig. 4.

While many studies have indicated that PBSL improves students' critical thinking skills, this is the first known quantitative validation of this concept [25]. 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. [26] measured the impacts of a semester-long project-based learning pedagogy in software development on students'

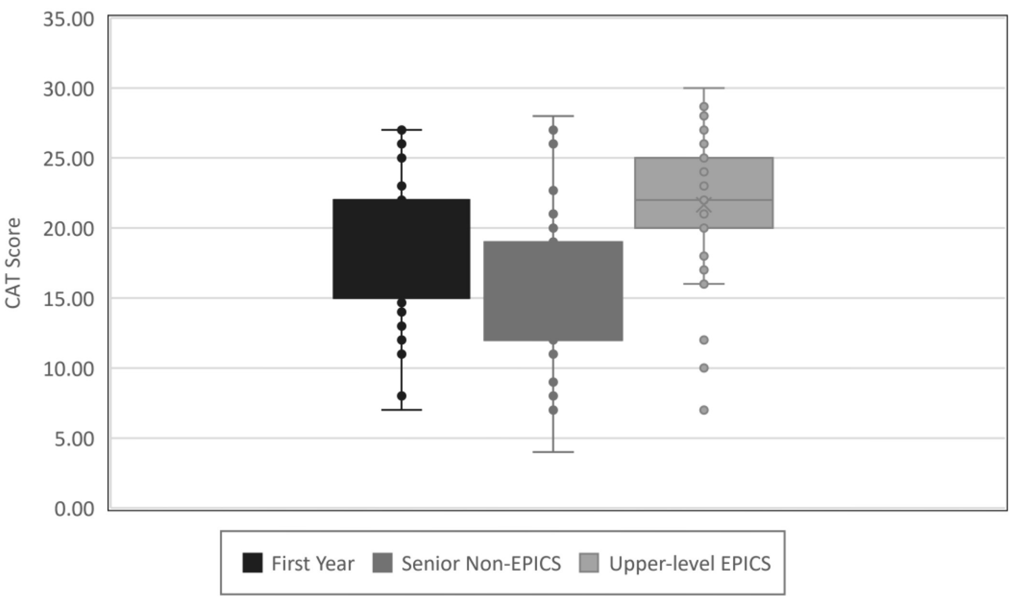


Fig. 4. Critical Thinking Scores as Assessed by the CAT.

critical thinking skills and found an 11% increase in critical thinking skills from pre- and post-semester assessments. Ahern et al. [11] 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.

3.2 Intercultural Competency

Analysis of IDI results, particularly the developmental orientation, was completed as shown in Fig. 5. 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 [16]. 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 using all combined data at an 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) demonstrated a significant increase (alpha 0.05) with participation in 3 or more semesters of EPICS service learning courses (n = 82).

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. [27] applied the Miville-Guzman Unvierality-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. [25].

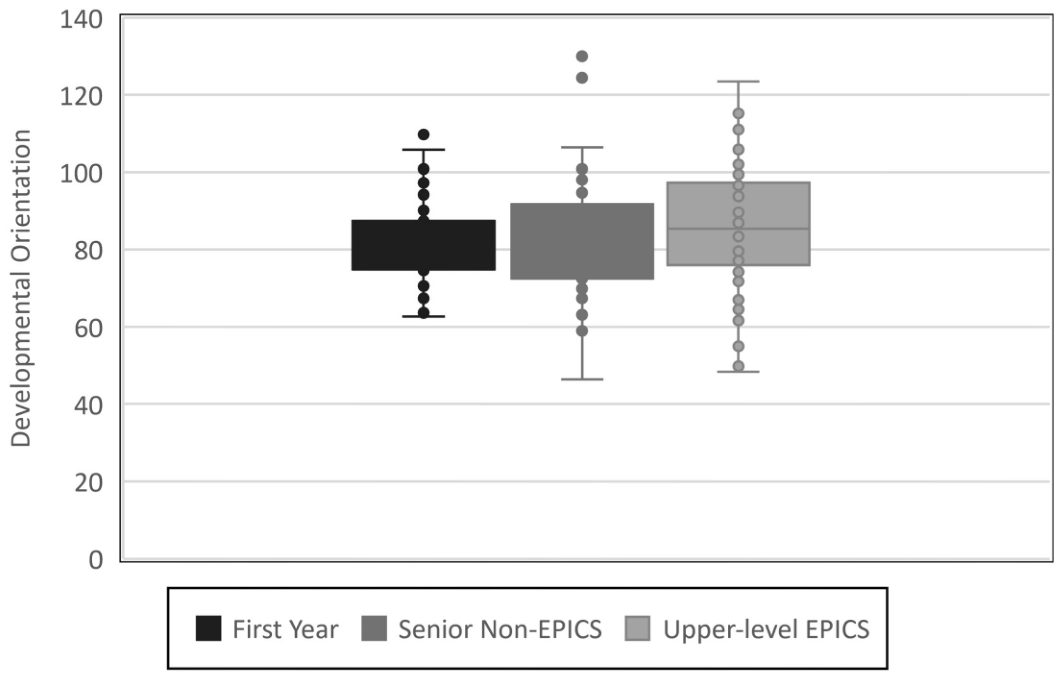


Fig. 5. Developmental Orientation Scores as Assessed by the IDI.

3.3 Other Professional Developmental Measures

As described in the Methods section, focus groups were used to collect information about student participants' perceptions on the influence of the program on additional indicators of professional development. During these focus groups, students were asked about the influences of EPICS participation on their perception of: stakeholder involvement in the design process, attitudes towards engineering design, sustainable design, multi-disciplinary design, and culture and diversity. For the analysis, we included key words or phrases and counted the frequency at which the term was indicated either directly or paraphrased. For example, a student comment citing the difference between tolerance and acceptance or understanding and appreciation is included as a strength under diversity/cultural. Similarly, a student comment expressing concern over graduation credits is counted as a concern under logistics but a student citing continuation of the program despite a limit towards graduation credit is listed as a strength under logistics.

The results of the focus groups (shown in Fig. 6) 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.

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 [8, 10, 25].

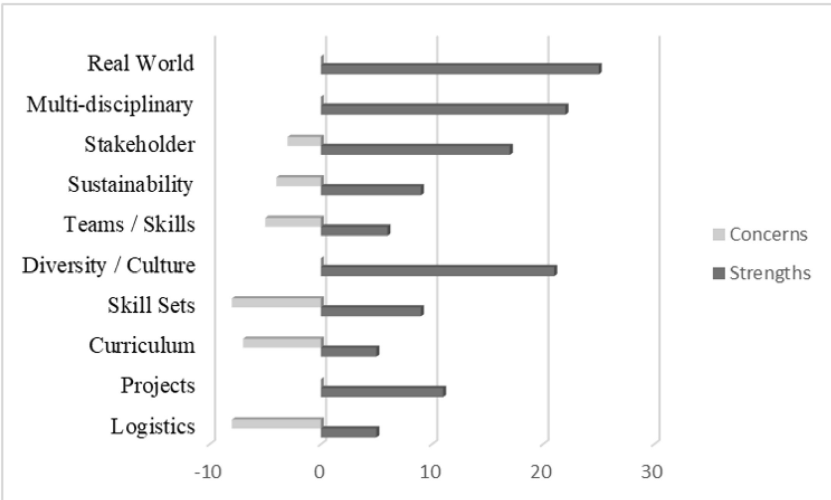
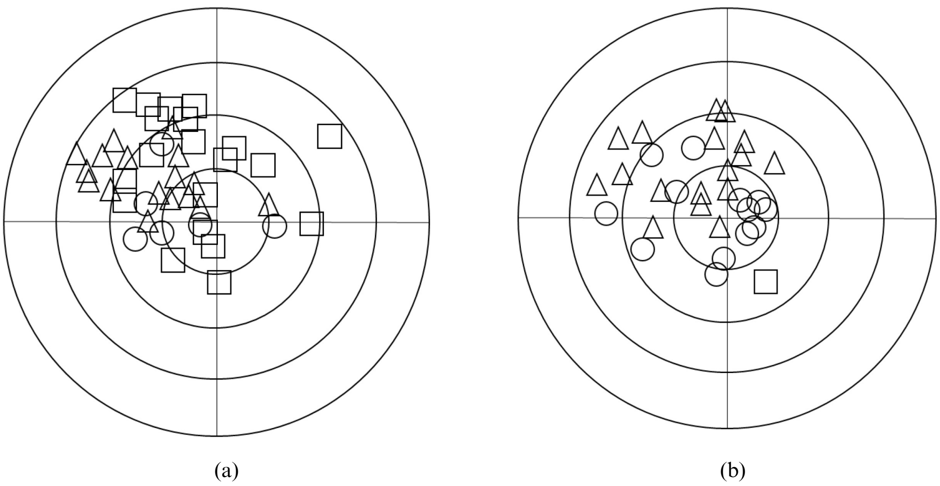


Fig. 6. Analysis of Focus Group Sessions for EPICS (2017–2019)



(a) (b)

Fig. 7. Comparison of Student Typologies between Two EPICS Programs: (a) Purdue University and (b) SD Mines. Triangles indicate typologies for male students, circles indicate typologies for female students, and squares indicate typologies where the gender is unknown.

Table 3. Correlation Between CAT and HBDI Profile Scores

	Analytical	Organized	Relational	Holistic	CAT
CAT	0.244	–0.133	–0.0822	–0.105	1

Table 4. Correlation Between IDI and HBDI Profile Scores

	Analytical	Organized	Relational	Holistic	DO
PO	–0.179	–0.126	0.233	0.241	
DO	–0.147	–0.110	0.244	0.164	1

3.4 Cognitive Diversity

The results of the HBDI typologies between all EPICS students at Purdue and all EPICS students at SD Mines is shown below in Fig. 7.

Fig. 7 indicates that EPICS students at SD Mines and Purdue are more cognitively diverse than what one would expect in a traditional engineering program, as compared to Fig. 3. EPICS students at Purdue appear to be slightly more cognitively diverse, however that program is more mature and more inclusive of majors other than engineering. Schar [28] showed that higher levels and a balance of analytical (upper left) and holistic (upper right) quadrant thinking styles are indicative of an entrepreneurial mindset in engineering students; this is consistent with literature, which indicates that entrepreneurs are most often dominant in the holistic quadrant [4, 17]. Consistent with literature [18], it is reasonable to conclude that in an effort to increase student diversity, it would be worthwhile for universities to explore options to engage different typologies of student learners through offering such types of programs.

3.5 Comparison of Typology, IDI, and Critical Thinking

Typology can impact a student's ability to think about solving problems. The conjecture is that diverse thinking is conducive to looking at problems from multiple perspectives resulting in better solutions [3, 4, 19]. For the EPICS dataset, there were 42 students that completed both the CAT and the HBDI tests. A multiple regression predicting CAT scores based on HBDI profile scores was tested, however, results showed very low correlations. A step-wise regression analysis indicated that the best predictor of CAT score, or critical thinking skills, was the analytical quadrant scores. Specifically,

$$\text{CAT} = 14.3 + 0.054^{*}\ \text{Analytical score} \qquad p = 0.115$$

With a p value of only 0.115, this result is marginally significant but is notable. A correlation between the CAT scores and each of the profile scores is shown in the correlation Table 3.

Typology might influence or be influenced by a student's intercultural competence. Specifically, if a goal of engineering design is to help solve societal problems, then it seems reasonable to assess if typological considerations help to promote a more developmental orientation (as measured by the IDI). A total of 91 students completed both the HBDI and the IDI. Conducting a step-wise regression of HBDI profile scores with IDI DO scores yields:

$$\text{IDI DO} = 68.7 + 0.17^{*}\text{Relational} + 0.087^{*}\text{Holistic} \quad p = 0.039$$

Table 4 shows correlations between HBDI profile scores and IDI perceived and developmental orientation scores. This suggests that while the analytical focus is predominant in most engineering curricula, intercultural competence is tied closely to the intuitive brain (relational and holistic quadrants). It stands to reason that if universities want to increase students' intercultural competence, then offering curricular approaches that engage and retain the intuitive brain, such as service learning, is beneficial. To the authors' knowledge, this is the first research to show a correlation between typological diversity and developmental orientation.

4. Conclusions

These studies investigated programs at two different institutions and indicate that there are clear benefits to students through their involvement in project-based service learning. Improvements in critical thinking skills was shown for students involved in EPICS for three or more semesters. Intercultural competency also increased with extended participation in the programs. Further, there are benefits to universities in offering these programs, as they offer opportunities for the persistence of cognitively diverse students.

Two EPICS Programs were included in these studies that approached team management and faculty loads slightly differently, they both meet the core attributes described for EPICS programs making it likely that the findings in this study would be evident on other campuses with EPICS programs. These programs also align with the more general characteristics within the broader project-based service-learning pedagogy and the findings would likely be found in other programs. Future work could expand the investigation to other programs to examine variations on the approach to project-based service-learning.

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