Project MESA: Impact of a student-led service learning project on cultural intelligence and socially engaged design

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Abstract – The intersection of service learning and cultural intelligence has been established as a way for engineering students to gain vital formative experience and skills. Project MESA (Making Examinations Safe and Accessible) is a service learning team founded to address the barriers to gynecological screenings in Nicaragua, which are believed to contribute to high cervical cancer incidence. Through this study, the service learning approach of the project is evaluated in its effectiveness in developing cultural intelligence and promoting mastery of the socially engaged design process through team participation. Results showed that students who had greater measures of sentiment for Project MESA displayed higher cultural intelligence. Through a qualitative review, students were also able to identify the major components of socially engaged design. Students who participated in Project MESA also reported that their approach to the engineering design process was enhanced by service learning. Furthermore, students responded to what they felt they were able to gain from participation in the project. A number of themes were identified, most common of which were prototyping, cultural sensitivity, and partner communications.

Index terms: cultural intelligence, multidisciplinary, service learning, socially engaged design

INTRODUCTION

Service learning, or community engaged learning, projects allow students to coalesce academic work and community service.ⁱ Many instructors include service learning to contextualize course content. Service learning is especially important for engineering projects targeting global challenges because it allows students to engage and collaborate across diverse communities.ⁱⁱ As defined by Hatcher and Bringle, service learning is “a credit-bearing educational experience in which students participate in an organized service activity that meets identified community needs and reflects on the service activity in such a way as to gain further understanding of the course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility.”ⁱⁱⁱ Service learning is often described with respect to four components: service, academic content, partnerships and reciprocity, and analysis and reflection.^{iv} Service is defined by working with underserved communities, often done through direct contact. Academic content consists of the engineering principles and concepts students learn through coursework.^{iv} Partnerships and reciprocity describe the relationships contributing to the project’s goals, encouraging students to work with the community instead of for the community. Finally, analysis and reflection is the process of making connections between academic content and larger social issues.

A main challenge in modern day globalization is miscommunication in businesses due to cultural differences, making Cultural Intelligence (CQ) important for individuals working in a variety of environments.^v Defined as the “capability to function effectively in intercultural contexts,” CQ is shown to be positively correlated to beneficial traits including cultural adjustment, leadership, interpersonal skills, and task performance.^{vi,vii} Cultural adjustment allows for constituents to better establish diverse relationships due to increased agreeability and open-mindedness.^{vii} Skills associated with CQ are therefore important in establishing career success in a globalized world, making CQ development vital for educational settings.^{vii} In pursuit of quality career preparation, educational initiatives are potentially able to benefit from incorporating CQ development.

Previous literature shows many positive outcomes from integrating service learning and cultural intelligence into engineering design programs. The Humanitarian Engineering (HE) service learning program at The Ohio State University (OSU) has demonstrated that such programs tend to increase cultural and ethical awareness and greater collaboration amongst participants.^{viii} Another program at Kennesaw State University found that as opposed to traditional project learning, service learning projects improve student retention and perceptions of their future careers.^{ix} This claim is further supported by “Project Ulysses,” which sends participants abroad to get an in-depth experience with service learning in engineering across cultures. These projects support that service learning oriented programs enhance the potential for participants to be responsible global leaders.^x Existing literature points towards the importance of cultural competence while working on diverse teams. An engineer’s work is inherently collaborative and requires working within diverse groups. Cultural competency enhances collaboration with diverse teams.^{xi}

Project MESA (Making Examinations Safe and Accessible), is another example of a community engaged learning project in the field of engineering. However, Project MESA is unique from most projects in that it is both multidisciplinary and student-led. Due to these features, this study is important because it examines components of Project MESA that are important for student development. This study uses a mixed-methods approach to analyze the following research

question: how does participation in Project MESA influence cultural intelligence and students' approach to the engineering design process?

Project MESA background

Project MESA is a student-led initiative committed to facilitating access to gynecological examinations in low resource communities through the design of a portable, affordable, and safe gynecological table. Nicaragua has the second highest cervical cancer incidence rate in South America. About 677 women are diagnosed with cervical cancer, 409 of which die each year.^x Women in rural areas are reliant on the mobile clinics that arrive at their communities. However, clinicians are limited to the equipment they can carry, and heavy, bulky gynecological exam tables are especially difficult to accommodate. As a result, exams are performed on the most convenient surface, which is often unsanitary and uncomfortable for patients. This can also yield compromised test results. Project MESA's design specifications are based on multiple in-country meetings with partner communities and clinics in Nicaragua to ensure that the table meets the medical needs of the community and that the device can be integrated into the community.

Project MESA, founded in 2010, is a multidisciplinary team composed of a diverse set of students. The team demographics as of Fall 2020 are represented in Table I. Due to the circumstances caused by the COVID-19 pandemic, no new members were recruited in Fall 2020. Students are typically recruited through university-wide informational events and are asked to complete an application and interview with members of the team. Consequently, there are fewer first and second year students than in previous years. With the exception of low numbers of first and second year students, the demographic characteristics of this cohort are representative of the team in past years. Although there are proportionally more male engineers (73%) at the university, Project MESA tends to have more female students due to the nature of the project focusing on women's health (73%).

TABLE I
DEMOGRAPHICS OF STUDENTS IN PROJECT MESA DURING THE 2020-2021 SCHOOL YEAR

Demographics	Number of Students	% (n=22)
Gender		
Male	6	27
Female	16	73
Age		
≤19	3	14
20	9	41
21	8	36
≥22	2	9.1
Year		
Freshman	0	0.0
Sophomore	2	9.1
Junior	13	59
Senior	7	32
Major		
Biomedical Engineering	8	36
Mechanical Engineering	5	23
Public Health	3	14
Industrial Operations Engineering; Business	3	14
Biology Related Majors	3	14
Committee		
Table	13	59
Business	9	41

Project MESA and service learning

Project MESA incorporates the four components of service learning: service, academic content, analysis and reflection, and partnerships and reciprocity.

Service: Project MESA provides prototypes of their gynecological examination tables for free to partners in Nicaragua (see Figure I). The design process used is consistent with the principles of Socially Engaged Design (SED). SED refers to the innovative ideation process that seeks to alleviate a need specific to a certain community by understanding the social context through collaboration with the community itself.^{xii}

Academic Content: Over the last four years, Project MESA members have had the option to participate in a for-credit curricula called the Multidisciplinary Design Program. The program requires a number of assignments throughout the term, which are evaluated by an engineering faculty advisor. All project members collaborate on graded deliverables for their project team and have one-hour meetings with a corporate mentor weekly for advising and feedback on their progress.^{xiii} Some examples of concepts students have learned while working on assignments are Computer-Aided Design (CAD), business modeling, and impact analysis. Through these additional reports, the analysis and reflection component of service learning continuously occurs so that students connect academic content to service. During the past two semesters in Winter 2020 and Fall 2020, approximately 46% and 59% participated in the Multidisciplinary Design Program respectively. The vast majority of participants join Project MESA during their first and second years and elect to seek credit from their second semester onward until graduation (approximately 5-7 semesters).

Analysis and Reflection: Analysis and reflection is also an important component of the in-country meetings with community partners. When meeting in-person, team members conduct interviews and surveys with clinicians and patients. This feedback is later analyzed for further improvements upon our prototype and interactions with our community partners. Furthermore, while completing MDP deliverables throughout the semester, students reflect on the broader context of the work as well as technical aspects they have contributed to the team through an accountability report and semester presentation. In these assignments, students report on their academic goals, personal growth, and progress and impact with community partners.

Partnerships and Reciprocity: Project MESA demonstrates the partnerships and reciprocity component of service learning by traveling to Nicaragua to visit the partner communities roughly every two years. These student-led trips are funded by both team-wide and individual grants and scholarships from various university sources. Approximately eight to ten students participate each trip. Project MESA has established three partnerships with nonprofit organizations in Nicaragua that aim to improve healthcare in low resource communities. During trips to Nicaragua, the table is evaluated by physicians and community members directly, and feedback is collected to inform the next iteration created by the students on Project MESA. At least one student is fluent in Spanish, and community partners are bilingual. The purpose of this fluid communication is to ensure that the innovation adequately meets the users' needs. During the academic year, Project MESA maintains connections with these organizations through bi-annual virtual meetings.

FIGURE I
PORTABLE GYNECOLOGICAL EXAMINATION TABLE MADE BY PROJECT MESA (PROTOTYPE ZETA 2.0)

FIGURE II
PARTNERS ASSEMBLING PROTOTYPE DURING 2019 TRIP TO NICARAGUA

METHODS

Data Collection and Recruitment

Project MESA participation, effects on cultural intelligence, and student knowledge of socially engaged design were collected from 19 current and past students of Project MESA. A Qualtrics survey was sent to 53 current and former students (35.8% response rate). All students surveyed, except for one, have participated in MDP for credit. However, all participants involved in Project MESA have participated in MDP assignments regardless of enrollment for credit. Survey questions measured participation, cultural intelligence, and participant knowledge of socially engaged design. Additional questions collected demographic information of the participants.

Prior to data collection, the study was approved by the University Institutional Review Board (HUM00183434). Current and alumni members were recruited using rosters of the team. Participants were emailed the survey initially using individualized Qualtrics links. Responses were completely anonymized, and the survey took 8-10 minutes to complete. Participants were sent follow-up messages during the survey collection period. Inclusion criteria comprised of participants aged 18 years or older.

Survey Instrument Design and Measures

The survey included three measures: participation, cultural intelligence, and understanding of socially engaged design. The participation measure was further stratified into three sub-categories of commitment, effort, and sentiment.

Participation Measures: Survey measures for participation were compiled using previously validated measures.^{xiv,xv,xvi,xvii} Measures of participation were grouped into three categories based on previous literature: commitment, effort, and sentiment (Table II).^{xiv}

Measures of Commitment: Time spent working on Project MESA was used as a measure of commitment to the organization. In order to account for varied membership periods and work done at different periods, we chose to measure time commitment on two bases: years and hours per week (Q2&3 on the survey).

Measures of Effort: Previous literature has found that effort beyond time required can be associated with willingness to work beyond expectation.^{xv} An open-ended question had participants describing the type of work they did. Participants were surveyed about participation in leadership roles and travel opportunities as displays of effort and engagement (Q4-8). Participants were also asked to rank themselves on the amount of effort they feel they put into Project MESA as well as their willingness to go beyond expectations (Q9&10).

Measures of Sentiment: Sentiment, positive attitude, and collaboration with others are measures of participation and engagement.^{xvi,xvii} Awareness was measured through the knowledge of community partners and familiarity with the mission (Q11&12). Intra-collaborative activity was measured through understanding members' relationships with team members and collaborative activity (Q13). To measure the members' attitude towards the team, participants were asked to consider their own level of passion (Q14), as well as whether or not they felt a sense of pride through their affiliation with the organization (Q15). A question about whether members' experience had an external influence or impact on their lives, primarily through career enhancement, was also included (Q15).

Cultural Intelligence Measures: The shortened version Miville-Guzman Universality-Diversity Scale (MGUDS) was used to measure cultural intelligence amongst participants.

Previous literature has validated both the full and shortened form of the M-GUDS measures.^{xviii} The shortened MGUDS survey has also been administered and validated amongst engineering students and participants of service learning programs.^{xix} Three subscales within the shortened MGUDS survey (shown in Table II) are: diversity of contact, relativistic appreciation, and comfort with differences.^{xviii}

Measures of Knowledge of Socially Engaged Design: Questions on the survey included one, five-point Likert-scale question developed by the study team asking participants to rate their knowledge of defining socially engaged design. Additional open-ended questions asked participants to define socially engaged design. Remaining open-ended questions were aimed at understanding participant experiences within the team and with socially engaged design.

TABLE II
CRONBACH'S ALPHA FOR PARTICIPATION AND CULTURAL INTELLIGENCE SCALES

Participation	Cronbach's alpha
Effort scale*	0.157
1. Have you held/hold any sub-committee leadership positions?	
2. Did you travel for Project MESA (to Nicaragua or otherwise)?	
3. Please indicate your agreement: I would only dedicate as much effort as is necessary towards Project MESA	
4. I had/have gone above expectations on a given task	
Commitment scale	0.243
1. How many years have you been involved with Project MESA?	
2. On average, how many hours per week did you dedicate to the project?	
Sentiment scale	0.738
1. How knowledgeable are/were you of our global partnerships while on the team?	
2. How familiar are you with Project MESA's history/mission?	
3. How often did you collaborate with other members for your work?	
4. How passionate are/were you about Project MESA?	
5. Please indicate your agreement: I feel proud/excited to be/have been on Project MESA	
6. Please indicate your agreement: I feel as though I am close and work well with at least one or more other members of Project MESA	
7. Please indicate your agreement; Project MESA has had some influence or reinforcement on my career or academic goals and interests	
Total participation scale	0.540
Cultural intelligence	
Diversity of contact scale	0.778
1. I would like to join an organization that emphasizes getting to know people from different countries	
2. I would like to go to dances that feature music from other countries	
3. I often listen to music of other cultures	
4. I am interested in learning about the many cultures that have existed in this world	
5. I attend events where I might get to know people from different racial backgrounds	
Relativistic appreciation scale	0.606
1. Persons with disabilities can teach me things I could not learn elsewhere	
2. I can best understand someone after I get to know how he/she is both similar to and different from me	
3. Knowing how a person differs from me greatly enhanced our friendship	
4. In getting to know someone, I like knowing both how he/she differs from me and is similar to me	
5. Knowing about the different experiences of other people helps me understand my own problems better	
Comfort with differences scale*	0.299
1. Getting to know someone of another race is generally an uncomfortable experience for me	
2. I am only at ease with people of my race	
3. It's really hard for me to feel close to a person from another race	
4. It is very important that a friend agrees with me on most issues	
5. I often feel irritated by persons of a different race	
Total cultural intelligence*	0.787

*Negatively worded items were reverse coded prior to analysis

Statistical Analysis

Data was first compiled in Qualtrics and later exported to Statistical Package for the Social Sciences (SPSS) version 27 (IBM, Chicago, IL) for analysis.

Quantitative Analysis: Descriptive statistics and exploratory data analysis for demographic variables, participation, cultural intelligence, and self-rated knowledge on socially engaged design were conducted. Tests for whether variables were normally distributed were conducted prior to running descriptive statistics. Cronbach's alpha was calculated for subscale and total scales for participation and cultural intelligence to assess internal consistency and reliability. Bivariate analysis with non-parametric Spearman correlation between participation scores, cultural intelligence scores, and self-rated knowledge of socially engaged design were conducted. All analyses were two-tailed and deemed significant at the 5% level.

Validation of Survey Instrument: A total of 19 participants responded and completed the survey. Participation measures had three domains: effort ($n=4$), commitment ($n=2$), and sentiment ($n=7$). Only the sentiment subscale had an acceptable internal consistency (standard Cronbach's α) of 0.738. Cultural intelligence measured using the MGUDS survey had three domains: diversity of contact ($n=5$), relativistic appreciation ($n=5$), and comfort with differences ($n=5$) with responses ranging from 1 (strongly disagree) to 6 (strongly agree). The diversity of contact ($\alpha=0.778$) and relativistic appreciation subscales ($\alpha=0.606$) had good and acceptable levels of reliability, respectively. The total cultural intelligence scale which took all questions in the cultural intelligence survey together had a good level of internal consistency ($\alpha=0.787$). Due to the lower number of responses, confirmatory factor analysis was not conducted.

Qualitative Coding: Participant definitions to socially engaged design had a median of 30 words (range 11-71 words). Participants' report of important takeaways of the engineering design process had a median of 33 words (range 9-67 words). Self-reported challenges encountered by participants when working on Project MESA had a median of 21 words (range 6-113 words). Three rounds of inductive coding were completed to examine the open-ended response questions. In the first two rounds, four co-investigators discussed themes present in each response and created a codebook as seen in Table AI of the Appendix. Another round of coding was completed by one co-investigator not involved in the previous rounds. The degree of agreement was quantified using an interrater reliability test with the kappa statistic. Q1 (Participant definition of socially engaged design) showed moderate agreement ($\kappa=0.444$) between raters. Q2 (participant takeaways) and Q3 (self-reported challenges) demonstrated substantial agreement ($\kappa=0.753$ and $\kappa=0.751$) between raters. The second round of coding from four co-investigators was used in the final results after the interrater reliability test was conducted.

RESULTS

Participant Demographics

Demographic characteristics collected included major, minor, and committee of the respondent. The highest percentage of participants were biomedical engineering majors (36.8%) followed by mechanical engineering (26.3%). The highest percentage of participants also reported having no minor (42.1%) followed by multidisciplinary design (15.8%). The majority of participants were part of the table committee (57.9%) followed by business (36.8%) (see Table III). Our sample characteristics are representative of Project MESA's makeup during the 2020-21 school year.

TABLE III
DEMOGRAPHIC CHARACTERISTICS OF SURVEY PARTICIPANTS

Characteristic	N	%
Major		
Biology, Health & Society; Sociology; Microbiology	2	11
Biomedical Engineering	7	37
Industrial & Operations Engineering	2	11
Mechanical Engineering	5	26
Public Health Sciences	3	16
Minor		
Business	2	11
Multidisciplinary Design	3	16
N/A	8	42
Other	6	32
Committee		
Business or both committees	8	42
Table	11	58

Quantitative results

The results of the Shapiro-Wilk test indicated that the variables were not normally distributed. The median, interquartile range (IQR), and range are summarized in Table IV. Descriptive statistics were summarized per item within subscale, by subscale, and by total scores across subscales for cultural intelligence. Individual items within the comfort with differences subscale as well as subscale score were not reverse coded prior to calculating descriptive statistics; however, when calculating the total cultural intelligence score, these items were reverse coded prior to calculating descriptive statistics. Descriptive statistics for the one question regarding self-rated knowledge on defining socially engaged design are reported as well.

TABLE IV
DESCRIPTIVE STATISTICS OF PARTICIPATION MEASURES, CULTURAL INTELLIGENCE, AND SELF-RATED KNOWLEDGE

	Median	IQR	Range	%
Participation Measures				
Effort subscale (out of 14)**	11.0	(9.5, 12.0)	(8.0, 13.0)	78.6
Have you held/hold any sub-committee leadership positions?	1.0	(1.0, 2.0)	(1.0, 2.0)	50.0
Did you travel for Project MESA (to Nicaragua or otherwise)?	2.0	(1.0, 2.0)	(1.0, 2.0)	50.0
I would only dedicate as much effort as is necessary towards Project MESA	2.0	(2.0, 3.0)	(1.0, 5.0)	40.0
I had/have gone above expectations on a given task	4.0	(4.0, 5.0)	(3.0, 5.0)	80.0
Sentiment subscale (out of 35)**	31.0	(29.0, 34.0)	(27.0, 35.0)	88.6
How knowledgeable are/were you of our global partnerships while on the team?	4.0	(3.0, 4.0)	(2.0, 5.0)	80.0
How familiar are you with Project MESA's history/mission?	4.0	(4.0, 5.0)	(3.0, 5.0)	80.0
How often did you collaborate with other members for your work?	5.0	(4.0, 5.0)	(3.0, 5.0)	100.0
How passionate are/were you about Project MESA?	5.0	(4.0, 5.0)	(3.0, 5.0)	100.0
I feel proud/excited to be/have been on Project MESA	5.0	(5.0, 5.0)	(4.0, 5.0)	100.0
I feel as though I am close and work well with at least one or more other members of Project MESA	5.0	(4.0, 5.0)	(4.0, 5.0)	100.0
Project MESA has had some influence or reinforcement on my career or academic goals and interests	5.0	(4.0, 5.0)	(4.0, 5.0)	100.0
Commitment subscale (out of 16)**	8.0	(6.0, 9.0)	(4.0, 10.0)	50.0
How many years have you been involved with Project MESA?	3.0	(2.0, 3.0)	(1.0, 4.0)	60.0
On average, how many hours per week did you dedicate to the project?	5.0	(4.0, 6.0)	(2.0, 7.0)	50.0
Total participation scale (out of 65)*	50.5	(46.3, 53.0)	(45.0, 56.0)	77.7
Cultural Intelligence				
Diversity of contact subscale (out of 30)**	27.0	(24.0, 28.0)	(15.0, 30.0)	90.0
I would like to join an organization that emphasizes getting to know people from different countries	6.0	(5.0, 6.0)	(4.0, 6.0)	100.0
I would like to go to dances that feature music from other countries	5.0	(5.0, 6.0)	(1.0, 6.0)	83.3
I often listen to music of other cultures	5.0	(4.0, 6.0)	(1.0, 6.0)	83.3
I am interested in learning about the many cultures that have existed in this world	6.0	(6.0, 6.0)	(4.0, 6.0)	100.0
I attend events where I might get to know people from different racial backgrounds	5.0	(4.0, 6.0)	(2.0, 6.0)	83.3
Relativistic appreciation subscale (out of 30)**	27.0	(25.0, 28.0)	(21.0, 30.0)	90.0
Persons with disabilities can teach me things I could not learn elsewhere	6.0	(5.0, 6.0)	(5.0, 6.0)	100.0
I can best understand someone after I get to know how he/she is both similar to and different from me	5.0	(5.0, 6.0)	(3.0, 6.0)	83.3
Knowing how a person differs from me greatly enhances our friendship	5.0	(4.0, 6.0)	(4.0, 6.0)	83.3
In getting to know someone, I like knowing both how he/she differs from me and is similar to me	5.0	(4.0, 6.0)	(4.0, 6.0)	83.3
Knowing about the different experiences of other people helps me understand my own problems better	5.0	(4.0, 6.0)	(4.0, 6.0)	83.3
Comfort with differences subscale (out of 30)**	8.0	(6.0, 9.0)	(6.0, 11.0)	26.7
Getting to know someone of another race is generally an uncomfortable experience for me	1.0	(1.0, 2.0)	(1.0, 3.0)	3.3
I am only at ease with people of my race	1.0	(1.0, 1.0)	(1.0, 2.0)	3.3
It's really hard for me to feel close to a person from another race	1.0	(1.0, 2.0)	(1.0, 2.0)	3.3
It is very important that a friend agrees with me on most issues	3.0	(2.0, 4.0)	(2.0, 5.0)	10.0
I often feel irritated by persons of a different race	1.0	(1.0, 1.0)	(1.0, 2.0)	3.3
Total cultural intelligence scale* (out of 90)	81.0	(76.0, 82.0)	(23.0, 66.0)	90.0
Self-rated knowledge of defining socially engaged design (out of 5)				
Based on my experiences with Project MESA, I am able to define the components of socially engaged design	4.0	(4.0, 5.0)	(2.0, 5.0)	80.0

*Negatively worded questions reverse coded prior to analysis

**Individual subscale item percentage calculations are out of total number of options available in the item; subscale total percentage calculations are out of subscale total points possible

Bivariate Analysis Between Measures of Participation, Cultural Intelligence, and Socially Engaged Design Knowledge

Non-parametric Spearman correlation analysis between effort, commitment, sentiment, and total participation scales, the three cultural intelligence subscales, total cultural intelligence scale, and self-rated ability to define socially engaged design were conducted. The results are summarized in Table V.

TABLE V
SPEARMAN'S CORRELATION RESULTS FOR MEASURES OF PARTICIPATION, CULTURAL INTELLIGENCE, AND SOCIALLY ENGAGED DESIGN KNOWLEDGE

	Diversity of contact subscale r p	Relativistic appreciation subscale r p	Comfort with differences subscale r p	Total cultural intelligence scale r p	Self-rated ability to define socially engaged design r p
Effort subscale	0.346 .248	0.435 .081	0.218 .400	0.548 .023*	0.315 .218
Commitment subscale	0.112 .658	-0.035 .891	-0.98 .698	.038 .880	0.229 .360
Sentiment subscale	0.520 .023*	0.516 .024*	0.306 .202	0.603 .006*	0.651 .003*
Total participation subscale	0.519 .040*	.503 .047*	0.335 .205	0.467 .068	0.657 .006*

Reflective Questions On Students' Approach To The Engineering Design Process

After the second round of coding was completed, a total of 20 themes were reported across three questions. Each of the themes were defined by the co-investigators. The five key themes students reported in Q1 are summarized in Table VI. The median number of themes per response was 3 (range: 2-5) and two responses had all five themes. The number of times each of these themes appeared was consistently high, except for the design process theme (nine responses). Q2 had seven noticeable themes that appeared in students' responses. The median number of themes per response was 2 (range: 1-4). The top three themes were "prototyping" (eleven responses), "cultural sensitivity" (ten responses), and "Partner Feedback" (seven responses). The third open ended response question recorded eight different themes. The median number of themes per response was 3 (range: 1-3). The most common themes reported in student's responses were "lack of skills" (seven responses) and "partnerships" (seven responses).

TABLE VI
DESCRIPTIVE STATISTICS OF THEMES IN OPEN-ENDED QUESTIONS

Q1. From participating in Project MESA, how would you define socially engaged design?		Q2. What are 1-3 important takeaways of the engineering design process you've learned by participation in Project MESA?		Q3. What challenges have you faced in the design or business process while working on Project MESA?	
	n of survey participants		n of survey participants		n of survey participants
Collaboration	16	Prototyping	11	Lack of Skills	7
Addresses a Need	14	Cultural Sensitivity	10	Partnerships	7
Community Centric	13	Partner Feedback	7	Engineering Design Process	6
Social Context	12	Internal Communication	6	Manufacturers	5
Design Process	9	Multidisciplinary	4	Cost	4
		Technical Skills	2	Student/Life Balance	3
		Dependence on External Partners	2	Team Dynamics	3
				Imposter Syndrome	3

DISCUSSION

Research Question: How does participation in Project MESA influence cultural intelligence and students' approach to the engineering design process?

This study found a positive association between participant sentiment and cultural intelligence in diversity of contact, relativistic appreciation, and total cultural intelligence. The total participation scale was also positively associated with the diversity of contact and relativistic appreciation subscale of cultural intelligence in addition to the effort subscale being positively correlated to total cultural intelligence scores. The study additionally saw a significant positive association between self-rated ability to define socially engaged design and both participant sentiment and total participation. Previous literature has largely centered on employee engagement in industrial settings. However, this research demonstrated that service learning helps students develop characteristics for the workplace.^{xx} Given the preparatory nature of such teams, student project teams like Project MESA can be understood to emulate workplace environments to some degree, allowing for findings regarding employee engagement to be applicable in the context of this study.

Employee sentiment has been previously implicated in employee engagement, determined through personal satisfaction, inspiration, and affirmation.^{xxi} Schaufeli and Bakker describe how an employee's positive affectivity surrounding the organization, marked by being attentive and alert, enthusiastic, inspired, and proud, is yet another sign of engagement. Furthermore, collaboration and feeling close to other members of a team can mark employee sentiment and engagement. Having positive interpersonal relationships with employees is related to creating supportive environments that aid employees in finding greater meaning and engagement with their work.^{xxii} Through these avenues, a strong emotional investment is cultivated within the employee towards the organization; this implies that having emotional investment binds the employee to the organization, its mission, and its values.^{xxiii} The results of this study are affirmed by this literature -- exuding a higher level of sentiment or participation toward a cause ingrained in a set of core values will increase a participant's identification with those values consequently. As a team dedicated to a global healthcare issue, Project MESA values and operates within cultural differences. This suggests that higher sentiment and participation towards Project MESA leads to higher cultural intelligence and awareness of socially engaged design.

The first qualitative question aimed to assess Project MESA's participants' understanding of socially engaged design. We coded themes based on this predetermined definition of socially engaged design: the innovative ideation process that hopes to alleviate a need specific to a certain community through understanding the social and collaboration with the community itself.^{xiii} Based on qualitative coding, five main components of this definition were relevant: Collaboration, Addressing a Need, Community Centric, Social Context, and Design Process.

Collaboration was the category that most respondents identified as a component of socially engaged design. This was defined as recognizing the need to work with a community through constant communication and feedback, which was present in many of the definitions provided by Project MESA members. Responses included phrases such as:

"Feedback is encouraged and changes are continuously made."

Addressing a Need was the second most identified component of socially engaged design, defined as students focusing on addressing the problems identified in the community and continuously gather their feedback to inform our design. A characteristic example of responses that contained this theme include:

“Designing for the community needs.”

Having a Community Centric approach was the next most identified component of socially engaged design and was defined as recognizing the necessity to prioritize the community’s needs over the students’. This is separate from the theme Addressing a Need because it puts particular emphasis on prioritizing the necessities of the community. Responses that included this idea had phrases such as:

“Efforts of the project ... align as closely as possible with the needs of the population in question.”

Responses that included a ‘social context’ met the definition of understanding that the social context in Nicaragua presents different challenges/barriers that may need to be addressed in the solution. Responses that touched on this idea included phrases such as the following:

“There is an understanding of the culture, language, and values of those who your design impacts, and that this understanding was a strong contributor in the outcome of your work.”

Themes from coding related closely to the actual definition of socially engaged design, suggesting that students who participate in Project MESA are well equipped to approach the engineering design process with cultural awareness. As proposed in current literature, designing with social engagement entails “gaining an understanding of the circumstances in which they seek to design” rather than merely deciding what to design.^{iv} Willis and Elbana notes that as engineering design shifts towards providing substantial contributions to human well-being, socially engaged design is a fundamental component to underscore community centered needs and design.^{xxiii} The findings in this article hold true for Project MESA, as students that gain socially engaged design skills are better equipped to work with the community.^{xxiii}

The second short answer question that was coded for themes examined students’ thoughts on the main takeaways of the engineering design process. The top three themes that resulted were Prototyping, Cultural Sensitivity, and Partner Feedback. Responses that provided an understanding of the importance of multiple iterations were considered to have met the criterion for Prototyping:

“It often takes many iterations of a design to land on a final product, and even that final design may not be a completely viable solution to the problem.”

Cultural Sensitivity, the second most mentioned theme, was coded for responses that emphasized the consideration of the context, culture, and background of the population for which the product is being designed. Many had responses with similar phrasing as the following:

“It is important to keep community values in mind when going through the design process, and it is also crucial to understand the access to resources of the community you're working with before and throughout the design process.”

The third most common take away that students mentioned was Partner Feedback. This included responses that highlighted communication and collaboration with partners:

“It is important to get feedback from the patients directly, what is most efficient for one community may not work in another one just because it is logical.”

Thus, from the results of Q2, Project MESA students showed comprehension of the notion that the engineering process can be ongoing. They also showed awareness of the cultural components that influence the engineering process. By frequently mentioning partner feedback in addition to cultural sensitivity, students exemplified an understanding of the importance of interacting with those in different cultures, not only learning about them.

Q3 asked participants about challenges they had faced in Project MESA. The top three coded responses were the categories Lack of Skills, Partnerships, and the Engineering Design Process. The theme Lack of Skills encompassed challenges that dealt with a students' lack of knowledge upon joining the team. Some representative responses are the following:

“I have also found it a challenge to work on impact reports and communication of data without a strong statistical background.”

“Not immediately knowing how to tackle an engineering/design problem.”

Next, Partnerships grouped together any challenges encountered by working with our various clinical partners in Nicaragua. These issues included cultural differences as well as communication issues:

“Communicating with partners due to differences in schedules and countries has been an ongoing challenge.”

Lastly, the Engineering Design Process entails all challenges involved with the prototyping and design process:

“[It has been a challenge] making the design easily manufacturable and cost-effective.”

These challenges are all multifaceted issues that students learn about as their time on the team progresses. Both the Lack of Knowledge and the Engineering Design Process themes point to students' absence of technical skills and experience on a project team. On the other side of the spectrum, the Partnerships theme shows that students are conscious of the cultural differences present between themselves and the end users of their work, and are constantly working to close this gap.

The outcomes from Q2 and Q3 are comparable with current literature. For example, engineering students at Virginia Tech who completed an abroad program also recognized themes of cultural understanding and the importance of communication due to the essential role cross-cultural communication played while working on their project.^x Furthermore, students at Virginia Tech reported challenges with personal skills and self-confidence. Some students indicated that they did not think they could participate in the project due to a lack of skills and knowledge. But after the experience, they grew more confident in their abilities.^x Students in Project MESA have had similar experiences overcoming self-doubt in their skills as reported by our theme Lack of Skills. The similarity between Q2 and Q3 with other literature demonstrates that the key takeaways students learn from service learning engineering projects are applicable outside Project MESA and positively influence student growth.

LIMITATIONS

The international nature of Project MESA's work tends to attract students of higher cultural intelligence to the team, which may account for consistently high cultural intelligence scores. Furthermore, there is also a potential of self-selection bias with people who are more favorable to Project MESA responding to the survey. Our survey was not validated and was filled out by a convenience sample, which was necessary due to the small size of the team in comparison to the number of data points we were looking to possess. Our survey responses yielded a small sample size of 19 participants, which should be taken into consideration when viewing this study. Additionally, subscales of sentiment, commitment, and effort in our survey design came from surveys used in other research projects not directly related to engineering. This could influence why the commitment and effort subscales were not substantially reliable. A final limitation is that the authors were unable to use pre- and post-surveys to measure cultural intelligence since students on Project MESA do not join and leave the team at the same time.

CONCLUSION

Our study examined how participation in Project MESA influenced cultural intelligence and students' approach to the engineering design process with the hopes of informing whether our service learning approach is valuable for student development. Since students cited cultural sensitivity and prototyping as some of the major takeaways from their experience working on the team, our findings supported the notion that students develop these critical skills. In addition, students were able to showcase apt understanding of the socially engaged design process, which refers to the process of integrating the design process into social context and cultural sensitivity.

As the necessity of cultural intelligence and socially engaged design becomes critical in the engineering field, our results inform successful methods through which cultural intelligence can be developed through service learning approaches, possibly applicable even in instances for education or extracurricular engagement. An interesting future direction could be an external evaluation of cultural intelligence of team members by our community partners. Our results show that sentiment towards the team's mission played a major role in the degree of cultural intelligence development through our team. This understanding provides critical insight for other service learning based project teams or initiatives that seek to develop cultural intelligence. It is able to inform that an emphasis on promoting participant sentiment is beneficial to increase cultural intelligence.

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APPENDIX

TABLE AI
CODEBOOK OF THEMES FOR OPEN-RESPONSE QUESTIONS

Q1. From participating in Project MESA, how would you define socially engaged design?	Q2. What are 1-3 important takeaways of the engineering design process you've learned by participation in Project MESA?	Q3. What challenges have you faced in the design or business process while working on Project MESA?
<p>Collaboration Recognizes the need to work with a community through constant communication and feedback.</p> <p>Addresses a Need Students focus on addressing the problems identified in the community.</p> <p>Community Centric Recognizes the need to prioritize the community's needs over the student's.</p> <p>Social Context Understanding that the social context in Nicaragua presents differently. challenges/barriers that may need to be addressed in the solution.</p> <p>Design Process An iterative process used to develop and improve upon a design.</p>	<p>Prototyping Process of refining a design by improving the last iteration, testing for failures, and developing a better product.</p> <p>Cultural Sensitivity Awareness that cultural differences exist between Project MESA and community partners in Nicaragua, without assigning value to these differences.</p> <p>Partner Feedback Process by which health clinic partners implement and evaluate the design, identifying improvements that could be made.</p> <p>Internal Communication Communicating and collaborating with other students on Project MESA.</p> <p>Multidisciplinary Utilizing different academic disciplines to approach a problem.</p> <p>Technical Skills Learning the abilities and knowledge needed to perform a task.</p> <p>Dependence on External Partners Having to rely on outside partners such as manufacturers in order for the team to make progress.</p>	<p>Lack of Skills Lack of knowledge and abilities needed to perform a task.</p> <p>Partnerships Communication and collaboration required to maintain a partnership with health clinics.</p> <p>Engineering Design Process Series of steps included in creating a design product.</p> <p>Manufacturers Collaborative process of getting parts manufactured for the team.</p> <p>Cost The cost our team incurs from prototyping, building, and testing. Cost can also refer to the price our health clinic partners would be willing to pay for a table.</p> <p>Student/Life Balance Using time-management to prioritize different responsibilities and needs.</p> <p>Team Dynamics Issues that arise while working within project MESA as a student group.</p> <p>Imposter Syndrome Individual doubts their skills or knowledge on the project leading to fear that they aren't actually contributing.</p>

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