A QUALITATIVE ANALYSIS OF SERVICE-LEARNING WITH ENGINEERING STUDENTS

By

Phyu Phyu Khin

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ABSTRACT

Service-learning is an effective learning method to increase necessary skills of STEM students. Therefore, it is necessary to increase engineering service-learning courses (Maloney et al., 2013). This study investigated how service-learning affects STEM students and what skills they retained after participating in a service-learning course. This paper is a qualitative study of STEM students in service-learning using students' reflections and their responses to interviews on what they experienced in service-learning courses. The engineering students in this study supported elementary students in a makerspace, carrying out hands-on activities. This paper illustrates how STEM students in service-learning classes contribute to community implementing activities in makerspace. The findings support the conclusion that a service-learning course can positively affect students' development of 21st century skills (Naik et al., 2020). This study shows that STEM students benefited from service-learning by increasing 21st century skills in communication, creativity, and leadership.

Keywords: service-learning, STEM students, 21st century skills

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Approved:

Dr. Audrey Meador December

Dr. Pam Lockwood-Cooke December

Dr. Nathan Howell December

Dr. Pam Lockwood-Cooke December

Dean, Academic College December

Dean, Graduate School December

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CHAPTER I

INTRODUCTION

Service-learning is a method of teaching students to connect their knowledge with a real-world application (Maloney et al., 2013). Service-learning is often referred to as a type of experiential education where learning takes place through the actual experience rather than in a traditional classroom environment" (Daniel & Mishra, 2017, p.1). Students in a service-learning class have a chance to apply knowledge to real problems. The traditional classroom teaching method may not provide enough knowledge for the students who want to work on real-world problems. To fulfill this gap, universities often offer service-learning classes for undergraduate students. After participating in service-learning course, students acquire positive outcomes such as retention in STEM fields, civic awareness, and better communication skills (Daniel & Mishra, 2017). For this reason, service-learning is different from traditional learning. In this paper, how service-learning affects engineering students were investigated. The research questions that guided this study are as follows:

(1) What skills are perceived by STEM students as being acquired after participating in service-learning?

(2) In what ways did service-learning in STEM affect STEM students?

This study examined the experiences of STEM students in a service-learning course and how it affected these students. The following section provides a theoretical

framework for this study and the next chapter is a review of literature pertinent to this study, including students' achievement in service-learning, the reason why we need more STEM students, and retention in STEM.

Theoretical framework

Service-learning has been used in the United States since the 1900s (Pacho, 2015). John Dewey is known as the father of service-learning, although he did not name a service-learning theory (Pacho, 2015). Dewey (1938) suggested that experience is essential for education to be authentic and that learning from the teacher is not enough. Eyler and Giles (1999) described Dewey's philosophy of learning as an educative experience that encouraged student's development. When the students have experience providing service, they understand the lessons better than those who are in traditional classrooms (Eyler & Giles, 1999). According to Eyler and Giles (1999), when students take service-learning classes, the expected outcomes include an improvement of social problem-solving skills, and personal and interpersonal development.

Pacho (2015) described how Dewey suggested that the institution provide opportunities that can connect the school and community, and service-learning is one of the strategies to join them. Service-learning classes in higher education are designed to provide benefits to communities (Collins et al., 2020). The components in service-learning support the students with motivation and contribute to their tasks' achievements (Collins et al., 2020). Service-learning is a combination of community service and academic study. Service-learning is relevant for STEM students because it can provide them with pedagogy that allows them to see the connections between school and their everyday lives (Collins et.al, 2020).

Learning outcomes

Service-learning is different from a traditional classroom environment. Service-learning associates academics with local community partners. In this way, service-learning can help students progress in social skills involving the community. The study conducted by Daniel and Mishra (2017) expressed affective outcomes, behavior outcomes, and content outcomes in a STEM-based international service-learning course. Participants in this course worked on projects which were based on environmental topics such as global biodiversity and conservation. The students helped society conduct a coastal bird survey to attain information on the bird population affected by oil spills, gather data on the type and amount of debris on the nearby beach, and educate the locals to be environment friendly.

Affective outcomes in the study by Daniel and Mishra (2017) are personal growth, increased self-efficacy, better communication skills, and leadership attitudes. The development of personal identity and self-efficacy are learning goals of service-learning. "The students are encouraged to react to their emotional reactions," (Daniel & Mishra, 2017, p. 2). Students in the service-learning class have to work in a team to implement the project (Daniel & Mishra, 2017). When students take part in this kind of project, they have to deal with people of different ages, races, and social classes (Daniel & Mishra, 2017). By carrying out the project, communication skills have been shown to improve (Collins et. al, 2020; Daniel & Mishra, 2017; Maloney et. al, 2013; Naik et.al, 2019).

A service-learning class environment allows students to behave more responsibly about social issues. The students notice the impact of humanitarian activities on their

surroundings (Daniel & Mishra, 2017). When students participate in service-learning, they believe they contribute positively to the community. The students in the study by Daniel and Mishra (2017) were extremely satisfied with their work. By having this kind of experience, the students involved showed an improvement of citizenship skills (Daniel & Mishra, 2017).

The students also had a chance to get educational benefits through service-learning. "The higher education communities focus on developing a course curriculum, which helps to connect the classroom knowledge to the real-world application to improve students' learning outcomes" (Daniel & Mishra, 2017, p. 2). The authors in this study agreed with other studies' content outcomes of service-learning (Collins et. al, 2020; Daniel & Mishra, 2017; Maloney et.al, 2013).

Service-learning and personal development

Self-knowledge. Students in service-learning find that they understand themselves better. One of the students in the study by Eyler and Giles (1999) was optimistic about her progress and became more confident after participating in service-learning. “It’s given me an opportunity to develop in ways that I wouldn’t have otherwise like being more confident in myself and my abilities and being more articulate about issues and being more of an advocate for these issues and just in conversations with friends and acquaintances,” (Eyler & Giles, 1999, p. 36). Her social dealing became better by interacting with people in the community (Eyler & Giles, 1999).

A Reward of Helping Others. The action providing service to the community separates service-learning from other kinds of learning (Eyler & Giles, 1999). When students like helping others and working in the community, they feel that it is rewarding

(Eyler & Giles, 1999). Moreover, when students work in groups and accomplish their projects, they are proud of themselves. The students of Eyler and Giles' (1999) study on service-learning felt the project gave them a more rewarding sense of accomplishment than that of traditional styles.

Spiritual-Growth. Students have shown to gain spiritual benefits from service-learning (Eyler & Giles,1999). Some students think service-learning is an excellent choice for their spiritual journey (Eyler & Giles, 1999). "Some [students] saw service as a definite opportunity to fulfill their religious commitment'' (Eyler & Giles, 1999, p. 36). "It's just good to give back something" (Eyler & Giles, 1999, p. 37). The students in the research by Eyler and Giles (1999) felt that they were giving something back to the community and were satisfied with what they did in service-learning.

Service-learning and interpersonal development

Interpersonal skills are essential when a service-learning project is implemented. Students may encounter problems in the workplace if they lack interpersonal skills (Eyler & Giles, 1999). In service-learning, students have to interact with instructors, peers, and the community in which they work. They have to take responsibility when they work together with an organization. By doing so, the quality of interpersonal relationships improves during the serving-learning course based on how it is arranged (Eyler & Giles, 1999).

Overall, this study explores what service-learning means, the impacts of service-learning on engineering students, and how service-learning is different from traditional classes. Service-learning outcomes are discussed, including students' personal growth, their improvement in social skills, and providing services to the community. The

following is a review of the literature on how other studies inspect service-learning in their research.

CHAPTER II

LITERATURE REVIEW

This study was conducted to observe how STEM students are affected by the service-learning experience. First, the researcher used the WTAMU library database to look for the articles in the literature review using keywords such as service-learning, engineering students, and STEM students. The researcher found thousands of papers in the area of service-learning. Then, the researcher needed to switch to more specific terms such as retention in STEM, student achievement in STEM, that focused on the required information for the current study. The next step was for the researcher to read through the abstract to analyze which articles were the best match for the current study. Some articles were written about service-learning, but they were not for STEM students. The researcher selected the writings where the authors described how engineering students were involved in a service-learning class. The researcher conducted a review of 50 research studies and selected 6 articles. The researcher believed these were more relevant to the purpose of the current study. A separate search was conducted with the new keywords such as qualitative service-learning, 21st-century skills, real-world application, makerspace, and John Dewey. The exact process was carried out for the second time to select more articles for the literature review. The researcher chose another 4 articles for the literature review. The databases EBSCOhost and ERIC provided most of the articles in the literature review. Finally, the number of articles the researcher selected

were ten articles which were relevant to the current study. The literature review is organized around two primary areas of inquiry:

1. Service-learning in STEM
2. Retention in STEM

Collins et al. (2020) conducted a quantitative study to investigate the potential of a service-learning experience to support STEM engagement for high school students who were designated at risk in math or science courses. In this study, 39 students participated in the Educational Pathways into College and Career (EPICC) program. Although the students who participated in EPICC were not required to have a very high GPA, they were given opportunities to participate in the service-learning project. This experience gave them a more positive outlook in their ability to contribute to the community (Collins et al., 2020). The students in EPICC also developed 21st-century skills such as communication and collaboration (Collins et al.,2020). The authors in this study concluded that the EPICC could provide an engaging experience for students improving their STEM knowledge and college and career readiness.

Sevier et al. (2012) conducted a quasi-experimental evaluation study to examine the effectiveness of using a service-learning method on introductory engineering students' motivation and the Accreditation Board for Engineering and Technology (ABET) program outcomes. The authors in this study compared the effectiveness of service-learning to that of the non- service-learning method. The number of participants in this study was 214 students who enrolled in an Introduction to Engineering course at the university. This course was a three-credit project-based lab course. Sixty-nine students in this study completed service-learning projects, and 145 students completed non-service-

learning projects. The curriculum for service-learning is based on client-based real-world problems, but the non-service-learning curriculum included project topics provided by the instructor. For example, service-learning students were building breadboard circuits or creating a device for a person with a disability and non-service-learning students were building composite beams and mousetrap car guided by the instructor. The service-learning and non-service-learning students were asked to express the most meaningful part of the projects they completed. The study by Sevier et al. (2021) showed that the course was designed to support engineering students in applying the engineering design process and viewing their capabilities to solve engineering problems. The authors concluded that a service-learning was more effective than a non-service-learning methods in impacting introductory engineering students' interests, recognition of relevance, and self-assessed engineering abilities using ABET program outcomes.

Sabat et al. (2015) used a mixed-method approach to investigate integrating a service-learning project into an undergraduate course curriculum to develop 21st-century skills. The participants in this study worked with the family businesses that were part of the university community's Management District. The authors designed an experiment to test the efficacy of the project in increasing twenty-first century skills. Sabat et al. (2015) compared the students who completed the project to those in a control condition. The number of participants in this study was 232 college of business students enrolled in six core course sections. Participants were in a team of 4 and had to work with one of the participating organizations. When the students in this study finished participating in the project, they had to complete a knowledge test of the four core management functions and measures assessing 21-st century skill development. A critical finding in this study

was that participants who completed service-learning projects increased their practiced and applied knowledge, teamwork skills, and civic engagement skills. Sabat et al. (2015) described that student who completed the project in this study obtained significantly higher scores on the management knowledge test compared to those in the control condition.

Ruth et al. (2019) conducted a mixed-method design in their study. The authors in this study combined pre-and post-test survey data from 259 matched high school students over two years. The authors in this study investigated how high school students' engineering mindsets and their views of engineering change after participating in project-service learning. The curriculum in this program was grounded in design education and service-learning pedagogies and looked to promote engineering. The students in this study were engaged in human-centered design focusing on the needs and uses for the end-stakeholder. The students in this study had to work with community partners by applying skills they learned in the class. The students needed to create engineering solutions to solve real-world problems. For example, they designed a robotics curriculum for a summer program for homeless children aged 5 to 12. The data in this study covered two separate sequential implementations of the Engineering Project in Community Service (EPICS) program. Ruth et al. (2019) first collected the data with an online survey. The second survey consisted of the open-ended narrative responses to questions. Critical findings in this study included that student reported increasing their critical thinking, problem-solving skills, communication skills and that the project fostered creativity. The students also learned how engineering was helpful in the community (Ruth et al., 2019). Ruth et al. (2019) concluded that the EPICS program could serve the

students very well, engaging the local community's needs and increasing student confidence as engineers and understanding the engineering process.

Webb (2016) conducted a qualitative survey with six undergraduate microbiology students and 13 elementary school teachers over a semester to explore the impact of service-learning experience on undergraduate students and elementary students. The author used an online survey to assess the impact of the service-learning project on the participants. The survey consisted of statements such as “the elementary students learned more about germs through presentation” and “participating in the project helped college students develop public speaking and teamwork skill”. The elementary teachers and college students gave responses through the Likert type scale. The author described that the elementary students enjoyed college students' microbiology lessons because they were in an active learning environment using hands-on activities about handwashing and how microbes were spread. Webb (2016) expressed that the participants in this survey agreed planning how to teach elementary students helped them learn more about their lessons. Webb (2016) concluded that the service-learning project in this survey had a positive impact on both elementary students and college students.

Bosman et al. (2017) used a mixed-method approach in their research. The authors in this study explored how service-learning supported interest in engineering education for underrepresented pre-engineering college students. The service-learning program in this study was the College of Menominee Nation’s (CMN) service-learning program which was designed for underrepresented engineering students. CMN provided college students with opportunity to mentor at-risk children. The total number of participants in this study was 63 who were planning to enroll or already enrolled in the

pre-engineering degree program. The participants in this study completed a pre-and-post survey to assess interest and self-efficacy related to renewable energy and STEM skills. Also, the students were asked to develop a "Philosophy of Mentoring Statement." The survey included multiple choice and Likert scale items which were taken from the Energy Literacy Survey to measure students' attitudes toward renewable energy. The Philosophy of Mentoring Statement included five opened-ended reflective prompts based on students' perceptions of mentorship goals and general experiences and the impact of the mentoring program. One of the findings associated with this study was the participants enjoyed helping at-risk children through the After School Program. Bosman et al. (2017) found that the college students liked to mentor and help the children develop skills in problem-solving, teamwork, and communication.

Daniel and Mishra (2017) conducted a qualitative study to measure students' affective, behavior, and content (ABC), global awareness outcomes, and impacts on long-term retention in STEM fields after participating in an international STEM service-learning course. The participants in this study were nine undergraduate students and seven graduate students who participated in service-learning activities. The authors compared the participants in the service-learning course with those who enrolled in the same class without the service-learning component. The data was collected from a Likert-type questionnaire, reflective journal entries, and responses from interviews after the course. This study found that students who took part in service-learning learned new skills, and they had clear, practical ideas for preserving nature. The students who did not participate in service-learning had superficial ideas with the same situation. Danel and Mishra (2017) described students in service-learning increased civic awareness. The

students' engagement in hands-on activities in service-learning facilitated their retention in STEM fields. The authors in this study hoped for students' future civic involvement according to the results in this study.

Naik et al. (2019) conducted a descriptive analysis to introduce service-learning to undergraduate engineering students through the Engineering Project in Community Service (EPICS) and the effects of community-based learning on student motivation. The authors in this study suggested students attained more knowledge through EPICS than studying in the lecture-based class. This study emphasized the importance of design thinking and its implementation. The students in EPICS worked with community partners to create products to help the community, such as designing a cordless grass cutter powered by solar energy and a solar-powered pool skimmer with a modern trash collection.

Bielefeldt and Canney (2014) conducted a mixed-method study to investigate the correlation between the social responsibility attitudes of engineering students and their participation in service-learning and extracurricular service activities of Engineers Without Borders (EWB). The participants in this study were first or senior year engineering students at five institutions. The total number of participants was 1,430 engineering students for three years. The initial survey happened in 2012 and the second was in April 2013, and the last poll was in 2014. One of the crucial findings in the study were the benefits of service-learning on students' social responsibility. The students who participated in service trips such as disaster relief volunteering or international humanitarian volunteering showed a significantly higher average social responsibility score, personal social awareness, and professional connectedness than those who did not.

The students who were involved in EWB had more substantial views of personal social awareness. The author concluded that the students' service-learning experiences in high school, both engineering and non-engineering college impacted their views of community service and social responsibility.

Maloney et al. (2013) conducted a mixed-method study to examine growth in an engineering service-learning course. The student learning and development assessment consisted of interpersonal skills, critical thinking skills, and other professional skills that were not easy to access in the classroom. Therefore, this study focuses on listening to the students' thoughts rather than having expectations. The participants in this study were 96 engineering students from different engineering programs. They were involved in mentoring students from local school teams that took part in the LEGO robotics challenge. After participating in service-learning for the three semesters, students showed significant improvement in communication skills, teamwork skills, Math and Science skills, problem-solving skills, creativity, and leadership skills. Students stated that they were also better in computer and technical skills, but this was not very statistically significant. Students reported that their math knowledge increased while they explained mathematical concepts to the children in service-learning. The authors in this study recommended that a journaling assignment should be viewed regularly by the instructors and discussed in the class. The new assessment should be provided at the beginning and end of the semester to let the students view their own growth and future as professional engineers (Maloney et al., 2013). The author concluded that the students in this study showed development over time after the service-learning.

The literature review aims to provide information about the skills engineering students improve in service-learning classes, the impacts of service-learning on engineering students, and the difference between engineering students who participated in service-learning and those who did not. Most of the studies in this literature review used a mixed-method approach and provided evidence that engineering students in service-learning classes improved communication skills, leadership skills, and design thinking skills. Participants in most studies worked with the community and created helpful products for the community. Participants in the current study offered similar service to the community, but this research is focused on the qualitative aspect of the experience. While many service-learning classes for engineering students have involved designing and developing beneficial devices, engineering students in this study acted as facilitators helping elementary students with engineering projects in makerspace. These students used their engineering skills in teaching roles. They also designed creative activities for elementary students such as building bridge, coding. The current study may fill this gap in the literature.

Student achievement

The service-learning course in the study by Daniel and Mishra (2017) mainly focused on environmental topics such as global biodiversity and conversation. The students in this course had to work with the community partners locally and internationally. They were involved in conducting biodiversity inventories, conserving, creating new habitats for native wildlife, and improving public literacy in the area. Students who took part in service-learning "readily reported plans to apply the skills

newly learned through service-learning activities" (Daniel & Mishra, 2017, p. 8). In this way, service-learning activities supported the exploration of new content.

Ruth et al. (2019) discussed student's participation in multiple community service projects over two years in their study. Students in the study by Ruth et al. (2019) conveyed that working on their Engineering Project in Community Service (EPICS) projects supported them to expand their self-efficacy in engineering. The students also stated that they viewed themselves as engineers and attained confidence in their engineering skills (Ruth et al., 2019).

In the study by Maloney et al. (2013), engineering students helped grade school students in preparing an eight-week LEGO Robotics competition that was held annually. While participating, engineering students encountered different steps of engineering design process such as brainstorming, testing, evaluation, and troubleshooting. Maloney et al. (2013) concluded that students in service-learning reported a significant increase in seven skills that engineers need in their professional lives: communication skills, teamwork skills, math and science skills, creativity, problem-solving skills, leadership skills, and time-management skills.

Collins et al. (2020) studied students who were engaged in a service-learning project that helped them build a portable, small-scale solar-electric system fitted inside a suitcase. The students made these suitcases and delivered them to schools, orphanages, and community centers in the developing areas that lacked electricity access. According to the study by Collins et al. (2020), students in service-learning classes attained a meaningful and engaging STEM-based service-learning experience. Students reported

increases in their solar power knowledge, science fascination, and attitude towards STEM (Collins et al., 2020).

Retention in STEM

Retention in STEM means more students want to enroll in STEM majors and they become interested in STEM-related careers (Daniel &Mishra, 2017; Collins et al., 2020). Women and minority students are earning degrees in STEM majors at a lower rate than other majors (Mau & Li, 2017). "The US Bureau of Labor Statistics (BLS) 2019-29 employment projections show that occupations in the STEM fields are expected to grow 8.0 percent by 2029, compared with 3.7 percent for all occupations," (Zilberman & Ice, 2021). As there is a rapid growth in the digital economy due to the expansion of the internet, computer occupations can be in high demand, and we need more students in STEM fields (Zilberman & Ice, 2021). According to the National Science Board (2015), the United States will encounter fewer STEM workers than needed in the workforce. Therefore, the growth of interest in science, technology, engineering, and mathematics (STEM) is crucial.

The impact of participation in service-learning consisted of increased retention in STEM fields (Daniel & Mishra, 2017). In the study by Daniel and Mishra (2017), international service-learning experiences encouraged students in higher education to pursue STEM-related careers. "[The] majority of the students [who participated in STEM fields] chose to pursue a STEM career inspired by their first-hand experience of integrating science with the community" (Daniel & Mishra, 2017, p. 8). The participants in the study by Daniel and Mishra (2017) were interested in working as a science teacher, science outreach director, and graduate research after participating in a service-learning

course. Webb (2016) also stated that involvement in the service-learning project made STEM students perceive a career in their respective fields. The microbiology students in the study by Webb (2016) agreed service-learning experience made them decide to seek a career in microbiology. Bosman et al. (2017) discussed that there were barriers for American Indian students to aim for STEM degree programs. However, the authors claimed that suitably designed service-learning could help to overcome the difficulties and retain the students in STEM fields.

Since this research focuses on service-learning with engineering students, the impacts and success of service-learning on the students, and implications of service-learning in the class are investigated in this section of the literature review. Moreover, the fact that an increasing number of STEM students in society is crucial was found. The new chapter focuses on how the researcher conducted this study, the outcomes of the students in service-learning, and the need for more research.

Literature Review Table

Table 1

Author/ Date	Research design	Participants	Service
Collins et al. (2020)	Quantitative	39 high school students	Provided compact, sustainable energy sources to developing areas
Ruth et al. (2019)	Mixed-method	259 high school students	Multiple community service projects over two years
Naik et al. (2019)	Descriptive	Undergraduate engineering students	Partnered with organizations to create products for the community
Bosman et al. (2017)	Mixed-method	63 undergraduate engineering students	Mentored at-risk children through hands-on STEM experience
Daniel and Mishra (2017)	Qualitative	9 undergraduate and 7 graduate students	Multiple community service projects
Webb (2016)	Qualitative	6 undergraduate microbiology students and 13 elementary school teachers	Conducted a microbiology workshop for elementary students
Sabat et al. (2015)	Mixed-method	323 undergraduate business students	Worked as employees in family-owned businesses
Bielefeldt and Canney (2014)	Mixed-method	1430 undergraduate engineering students	Multiple community service projects over three years
Maloney et al. (2013)	Mixed-method	96 undergraduate engineering students	Conducted a robotic workshop for grade school
Sevier et al. (2012)	Mixed-method	214 undergraduate engineering students	Designed adaptive projects devices for people with disability

CHAPTER III

METHODOLOGY

The aim of this study is to assess the effectiveness of service-learning for STEM students. We use qualitative research for this study because the researchers in this study gathered information through interviews. Case-study is an interpretive study where a thorough analysis is conducted of a program, a project, an event, or a case (Creswell & Creswell, 2018). The purpose of using case study in this paper is to investigate STEM students who participated in a service-learning class and what effects participation in service-learning had on students' achievement, retention, and professional knowledge acquisition. The service-learning environment in this study is a case study where the researchers describe the experiences of STEM students helping elementary students in makerspace.

The elementary school in the local area needed help to staff a makerspace with volunteers who were knowledgeable in STEM fields. Around this same time, a local university expanded on service-learning opportunities for STEM students. College students were offered a course with a service-learning opportunity participating in the elementary school makerspace. Students who joined the service-learning course facilitated activities in the elementary school to help K-6 students improve in STEM. They developed projects and activities for the makerspace and volunteered during makerspace hours. For example, they had to design and program a robot. Then, they

allowed elementary students to do the work by themselves. Later they were asked to reflect on the impact of the experience on their professional and educational expertise.

Participants

There were approximately fifty undergraduate STEM students, eighteen years of age or older, enrolled in engineering, computer science and mathematics class at a local university who served as the population for this study. These fifty students were spread over eight Fall and Spring semesters. Nine participants wrote the reflections on what they encountered in the service-learning class and five students agreed to be interviewed. Therefore, fourteen participants were included for the sample.

Data sources

The data for this analysis comes from a public four-year university. The engineering students who participated in the service-learning class were asked to write their reflections during the course and were interviewed after the course was completed. The participants were asked to write reflections on their thoughts and experiences in the service-learning course. Nine of the reflections are used in this paper. The participants who completed voluntary interviews were asked to answer open-ended questions based on interview protocol. Five interviews were analyzed in this paper. The interviews were audio- recorded and then transcribed. The interview question includes eight questions that are related to engineering students' participation in service-learning and their experience in a service-learning class when they worked with elementary students in makerspace (See appendix A for Tentative Student Interview Protocol). Participant anonymity was preserved by using numbers instead of their names such as Participant 1, Participant 2 and so on.

Data Analysis

Data analysis in this study used thematic analysis for the interviews and participants' reflections. Interviews were transcribed using otter.ai software. Transcriptions were exported into Microsoft Word, and line numbers were inserted. All interview transcripts were then printed for analysis. The researcher checked each transcript to make sure that there were no mistakes in the text. Then, each transcript was read carefully for a total of two times. Once the researcher became familiar with the data, initial coding was started. The researcher began placing colored markers on popular terms: for example, the color purple was used for the word “think", the color green was for the word "help", the color orange was for the word "fun", and so on. After marking each transcript, the researcher made a list of codes which consisted of the most popular words from the transcripts. Word frequency was added to the list. This concluded the first coding cycle.

After five days, the second coding cycle was initiated. The researcher printed out each transcript for a second time and conducted the same process as the initial coding. The researcher then made a second list of codes. The researcher returned to the original data and used the constant comparative method (Johnson & Christensen, 2020) to ensure the initial codes were valid.

The researcher then grouped the words into themes. Finally, the researcher rechecked themes for accuracy to see if there were any missing themes. Intracoder reliability was achieved through the repeated color-coding cycles at different times by a single coder (Johnson & Christensen, 2020).

The students' reflections were typed by the participants. Therefore, line numbers were added, and reflections were printed for analysis. The analysis was conducted similarly to the interviews. In this study, validity was achieved through multiple coding cycles and was cross-validated with students' reflections. Willie Tan (2018) stated "reliability can be enhanced by cross-checking [the researcher's] views with other sources of evidence" (p.100).

Researcher Bias

Researcher bias in a qualitative study is how the researcher's "personal background, culture, and experiences" (Creswell & Creswell, 2018) affect their interpretation of the information collected, how the themes are obtained from the data.

As a researcher in this study, I come from a third-world country, Myanmar, so English is not my first language. I used to be a freelance teacher in my country. In Myanmar, the education system uses a largely teacher-centered approach. The interaction between teacher and students is limited. Therefore, I am not familiar with active learning styles such as project-based learning, service-learning, and makerspace. Due to the encouragement of my English teacher in my country, I learned that it is acceptable to teach differently from others. My biggest motivation to become a teacher in the United States is to share my knowledge with the community.

In transcribing the interviews, I needed to listen carefully and interpret English, and slang used in everyday language. Coding everything in the transcripts accurately is not as easy as I thought. Regarding the data analysis, as a second language learner, I had to be aware that there is a different content meaning for the same word. For example, when I encountered the word " think" in the sentence, I figured out whether the

participants were referring to giving an opinion or talking about what they were doing about the project.

Furthermore, service-learning is a form of student-centered approach. For my literature review, I studied a lot of research discussing student-centered approaches, and in graduate classes I learned what the student-centered teaching method is. As I came from a teacher-centered educational background in Myanmar, service-learning is a new experience for me.

CHAPTER IV

RESULTS

This study aimed to understand what STEM students encountered in a service-learning class. By listening to interviews, information was obtained about STEM students' experience while working with students in elementary school. In analyzing the interviews data, five distinct themes emerged.

First, the researcher looked for single words that occurred most frequently. As a second cycle, the researcher grouped words and looked for themes. The researcher developed categories and looked for answers to research questions. When the interviewer asked the participants, what effect the participation in the course has had on their achievement in engineering, almost all participants answered “cool,” “fun,” and “good.” The researcher used the same color for these words and put them in the group named “positivity.”

Corresponding to the students’ learning styles, the researcher found the terms “think,” “hands-on,” and “create” in the interview data. The researcher used another color for these words and put them in the group named “creativity.” The word “communicate” was labeled with a different color. The frequency of the word “communicate” was found in the data when the participants answered the question: what effect, if any, has participation in this course had on your professional knowledge?

In the interviews and students' reflections, participants emphasized they had to "help" elementary students carrying out the activities in makerspace. They also defined service-learning as a method to support community. The researcher used a different color for the theme "support" in color coding. One of the lower frequencies found in the interviews was "struggle". Some students had difficulty in interacting with elementary students in makerspace. The Five tables shown convey accurate and purposeful outcomes that describe the STEM students' experience.

The results of the word frequencies can be found in Table 2.

Table 2

Words and Frequencies

Code	Frequency
Help	37
Think	29
Communicate	27
Cool	19
Hard	17
Create	17
Good	13
Fun	11
struggle	10
Experience	9
Hands on	7
Total	196

Then, as a second cycle, the researcher grouped the words and looked for themes as shown in Table 3.

Table 3

Themes in Coding

Words	Themes	Total Frequency
Create think	Creativity	46
Cool Fun good	Positivity	43
Help	Support	37
Communicate	Social Skill	27
Hard Struggle	Difficulty	27

Thirdly, the researcher paid attention to single words and sentences as a whole to determine the separate meaning of words in the sentence. The same words may have multiple meanings depending on the context. For example, as shown in Table 4.

Table 4

Word and its context

Word	Context
Think	Because I think it was always fun.
	It made me think about simplifying my design.
Like	Dude, like here at school.
	I like to go online.

Last, the researcher checked themes for the accuracy. Then the researcher made sure that no themes previously found were missing and the same results were obtained. After conducting all the steps above, the researcher identified which words affect the outcomes described in research questions as shown in Table 5.

Table 5

Outcomes and Themes

Outcomes	Words	Themes
Student's skills gained (Research Question one)	Communicate	Social skills
	Create	Creativity
	Think	
	Hands on	
Effects of service-learning (Research Question two)	Help	Support
	Struggle	Difficulty
	Hard	
	Cool	Positivity
	Fun	

Improving Social Skill

Feedback from participants in this study showed that they improved their communicative skills after joining service-learning classes. All five participants in this study needed to communicate with the staff in the elementary school and elementary students. They had a chance to interact with students, teachers, and staff in an elementary school while implementing activities in a makerspace. For example, when the interviewer asked participant 3 what achievements he obtained from a service-learning course as a student in engineering, he provided the following quote:

> "What I mean, being a civil engineer, it made you got to be able to communicate with people, you just can't be like a robot. He won't really get anywhere. I feel like [it] is mainly just communication, you know, but uh, participation was like, I did a good job. It was fun" (Line 113-115, p. 5).

When asked about what effect service-learning course had on their professional knowledge, Participant 1 stated, "Um, it, surprisingly enough made me much better communicate with people. Yeah, just talking. Like, I mean, when you talk to kids, especially that are that age, you have to adapt and get on that level" (Line 39-41, p. 2). When Participant 1 described his experience with communication in service-learning class on his reflection, he wrote, "Hard skills I was able to learn was how to talk to a younger generation and share my ways of how plan and design when faced with a challenge, even if doesn't relate to engineering" (Line 19-20, p. 1).

In the participants' reflections, Participant 2 shared, "I feel that I have improved a lot in communication after helping facilitate the makerspace this semester, specifically with the explanation" (Line 5-6 p. 1). These comments seemed to provide evidence that the

students were satisfied with their improvement in communication skills. They came to know how to communicate better with others working in a team.

Creativity in service-learning

More than half of the participants in this study indicated that they improved their creative thinking skills while implementing activities in makerspace with elementary students. It is found that the words "create" and "think" were said forty-six times and this created the theme "creativity" as shown in Table 2. Nearly all participants said that they had to think "outside of the box" because they had to figure out math-related problems they encountered. Participant 5 responded to the interviewer that he learned how to educate elementary students with creative skills while giving service at makerspace. He stated,

> "Well, definitely the younger kids, there is so much more creative, and it kind of open my eyes to wanting more childlike creativeness inside me because they came up with things that like were not even part of the project" (Line 177-179, p.8)

The participants' reflections in this study stated that they improved their creative thinking. Participant 1 affirmed, "While doing my service at makerspace I was able to learn in how to educate younger students in creative thinking teamwork, communication and designing methods" (Line 1-2, p.1).

Support and service-learning class

Almost all students revealed their experiences that they helped students in elementary school, and they also helped themselves improve skills in the service-learning

class. The word “help” can be found thirty-seven times as described in Table 2. When participants were asked how they defined service-learning, four out of five provided the same answers: "it was helping others in the community." Participant 2 replied, “A way to help your community, a service to your community, spreading your passions to your community" (Line 124-125, p. 6). Participant 5 shared his experience during the interview, and he said, “I guess, service I think of is like helping other people. So, like, in this case, it would have been helping the kids like learn. That's what service-learning is to me" (Line 98-99, p. 5). Participants in this study supported the elementary students to learn. According to Participant 4 in the interview, he said, "I like working with kids and stuff and helping them learn" (Line 141-142, p.6). Students in the service-learning stated that they enjoyed assisting elementary students with science projects. Participants not only helped the elementary students but also supported themselves in service-learning class. When asked about what effect, if any, participation in service-learning had on their achievement as a student in engineering, participant 4 stated, “Oh my, … [it] open[s] your eyes to different ways, like even with little kids, how they think about certain stuff like that, and like help[s] you apply to your future study” (Line 6-8, p.1).

Corresponding to Table 2 in this study, the total frequency of the word “help” was 37 and it was the highest frequency found in themes in students’ reflections. Participant 5 from the reflections expressed, “I worked on my teaching skills by helping kids to understand the directions of the various activities in the Makerspace” (Line 18-19, p.1). The theme “support” found in this study showed that students understood the service aspects of service-learning. They learned they could provide a service to improve elementary students’ skills.

Difficulty in a service-learning class

Four participants in this study reported they experienced difficulty implementing activities with elementary students in service-learning classes. The number of frequencies about the words such as "struggle" and "hard," and "challenge" found in this study is nineteen, as described in Table 2. The theme "difficulty" emerging provided the evidence that the participants in this study had to cope with challenges when they worked with students in makerspace. When asked whether or not participation in the engineering course had affected on their knowledge of design thinking, Participant 2 stated

> "So,…basically…when you make a project, you have to be able to explain it to someone who has no knowledge of engineering or design or analysis and things like that. So, it was very hard to just do an experiment without explaining it to the kids" (Line 39-41, p.2).

Participant 2 said that it is not easy to explain the elementary students engineering knowledge when they were in makerspace. Participants had to figure out how they could assist the students in understanding science. When elementary students were clear about what to do with the project, they enjoyed doing a hands-on activity. In the reflection by Participant 1, he said, "it was challenging to explain to younger students from grade two to grade [five] on how to understand and analyze from an engineering " (Line 15-16, p.1). In the student's reflection on makerspace, Participant 3 said,

> "Some of the challenges in makerspace provide computer technology that I came across for the first time. During my second challenge, I was given a tablet and told to teach the students on how to play a game. I knew nothing about the game

> or how to code it, but I was able to figure it out and make my own program" (Line 13-17).

In this way, STEM students encountered difficulty while they carried out the activities with elementary students in makerspace. STEM students found a way to solve the problems in the service-learning class.

Positivity of STEM Students

In this study, all participants believed that they had a helpful experience from a service-learning class and enjoyed working with elementary students. According to the data analysis on interviews and students' reflections, the theme "positivity" had the second highest frequency among all other themes found in the data. When Participant 5 was asked what he experienced in service-learning class, he replied, "The final project was really nice, having like, the freedom to do whatever we wanted and come up with something that was pretty cool, even though it was difficult" (Line 264-265, p. 12). When Participant 2 was asked if she felt that participation in service-learning course influenced her interest to major in engineering, she stated, "I was already studied engineering, but it definitely did boost me up into wanting to share that with other people" (Line 93-94, p. 4). Again, Participant 5 responded,

> "It was pretty cool seeing how the different ages of the kids had different abilities. And like, you can even learn from the kids when you were doing projects and stuff that was pretty fun" (Line 80-81, p. 4).

The participants in this study agreed that service-learning in this engineering course was very suitable for both engineering students and elementary students in

makerspace. They had a great time carrying out the activities. Participant 9 shared his experience with elementary students:

> "I had never seen ozobots, and I have to say that it was such a fun experience. This was a favorite for the students. I haven't taken a lot of classes on coding, but I love that it introduces coding early to students and that they get to be creative with their choices of codes" (Line17-19, p.1).

For each of what these participants said, it can be concluded that STEM students in this study are positive with what they learned from service-learning class. They also liked sharing engineering knowledge with elementary students.

Qualitative results in this section illustrated a positive impact on students' outcomes after participating in service-learning. Students in service-learning had better communication skills by dealing with staff in elementary school and elementary students in the makerspace environment. As service-learning was based on providing service to the community, students in this study helped elementary students create things using their engineering knowledge in the projects. Therefore, it was concluded that the participants' responses to interviews and their reflections in this study showed progress in communication, social skills, and creativity.

CHAPTER V

DISCUSSION

This section provides a discussion of the results of this study. Five themes: positivity, creativity, support, difficulty, and social skill were found related to students' experience in service-learning class. The current study found that service-learning helped students improve 21st century skills such as creativity, communication, and teamwork, in support of previously conducted studies (Daniel & Mishra, 2017; Maloney et. al, 2013; Naik et.al, 2020).

In a study by Kilgore et. al (2013), 25% of employers stated newly graduated engineering students had not enough communication and teamwork skills. They claimed one of the reasons was that they focused more on technical skills than professional and interpersonal skills. The study by Jang (2016) described that it is better preparation for the students in their working environment if STEM education could provide the necessary skills used in society. Daniel and Mishra (2017), Naik et. al (2020), and the current study found that students in service-learning improved 21st-century skills. This evidence of students' improving 21st-century skills indicates that students participating in service-learning are better prepared for their working environment in the future.

In response to the first research question, nearly all participants talked about their improvement in communication skills when they were in the service-learning class. Collins et al., (2020) expressed that the students who joined the service-learning course improved their communication skills. Participants in this study promoted creative thinking when they solved science and engineering problems corresponding to their projects. This study supported the research by Maloney et. al (2013), Naik et al. (2019), and Ruth et al. (2019). These studies found that students in service-learning achieved the necessary skills for an engineer, such as communication skills and creativity.

Support

Regarding the second research question, three themes were found: support, difficulty, and positivity. The current study's findings suggest that STEM students helped elementary students carry out projects in a makerspace, and the word "help" has the highest frequency in Table 2. They supported elementary students in designing their projects in the makerspace and explained the projects from an engineering point of view. Daniel and Mishra (2017) indicated that students who joined service-learning classes believed that they contributed to the community and were very willing to participate in social work. When the participants in this study were asked how to define service-learning in the interviews, they answered that it meant supporting the community. Bosman et al. (2017) found that the participants in their study helped at risk-children in the After School program develop valuable skills through the service-learning program.

Difficulty

Participants in this study reported that they struggled to guide younger students through science projects due to communication. One student in this study encountered technical issues and struggled with their own inexperience in one project. In the reflections, Participant 3 said that his main challenge was about computer technology; he had to figure out and make his own program although he had no programming experience. Some STEM students in the current study had difficulty interacting with elementary students. Participant 2 expressed that he was nervous when dealing with a group of elementary students because he was worried that the elementary students might not understand his way of explaining the engineering concepts.

Positivity

Most of the participants in this study mentioned that they had a great time creating things in the makerspace. Eyler and Giles (1999) asserted that students in service-learning were happy to work for the community, and they had a positive attitude about it. Webb (2016) described that microbiology students learned more about their own course material by helping elementary students in service-learning. After participating in a service-learning project, the microbiology students wanted to learn more about biology and pursue careers in that field (Webb, 2016). Participant 3 in the interviews stated that he enjoyed building things together with the elementary students.

Limitations

The purpose of this qualitative study was to identify the skills that STEM students improved when they participated in service-learning. One limitation was that the sample size was very small. Five participants completed interviews and nine reflections were received for the analysis. Demographic data on the participants was also missing.

CHAPTER VI

CONCLUSION

This study aimed to determine the effects of service-learning on engineering students through their participation in an elementary-school makerspace. As stated in the literature review, service-learning can be used to engage students in gaining leadership skills, creative thinking skills, and communication skills (Naik et al. 2020). Service-learning is an educational approach where students can learn through experience (Daniel & Mishra, 2017; Bosman et al., 2017). Using thematic analysis, five themes were determined to be most affective to students.

According to their reflections, the students in this study mainly improved in communication and creative thinking skills. Concerning the effects of service-learning activities, the participants in this study commented that they experienced the design thinking process while implementing the activities. Students in this study were occupied in an active-learning environment, helping elementary students in a makerspace. Jang (2016) stated that if STEM students practiced the necessary skills in school, they would be better prepared for the workplace. In a 2016 study, students who participated in service-learning improved their ability to solve social problems in society (Ocal & Altinok, 2016). Most participants in this study replied that they realized how to communicate with people by studying in service-learning classes. For this reason, introducing service-learning to the STEM students in this study benefited those students.

Suggestions for future research include having more participants in the survey to possibly explore different outcomes. If a larger population can be involved in the study, we can confirm the positive results with a bigger sample size.

The unique aspects of this study are shown through the students' experience in creativity and the various levels of the engineering design process. The engineering students had to develop a plan before carrying out the activities and needed to have elementary students involved in solving the engineering problems. When elementary students had difficulty in understanding advanced engineering knowledge, the engineering students had to take on teaching roles, which is atypical of the traditional engineering course work.

Service-learning is a teaching method that supports students to improve their soft and technical skills. Due to the effects of service-learning, engineering students in this study improved 21st century skills such as communication, creativity, and problem-solving. Students in this project took an active part when they implemented activities with elementary students. They were delighted and proud of helping and giving service to the community. Exploring how service-learning helps STEM students improve skills brings advantages; other higher education institutions can be aware of the benefits of service-learning in STEM courses through this study.

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APPENDIX A

Interview Protocol

Tentative Questions for interviews:

1. What effect, if any, has participation in ENGR 2101 had on your achievement as a student in engineering?
2. What effect, if any, has participation in ENGR 2101 had on your knowledge of design thinking?
3. What effect, if any, has participation in ENGR 2101 had on your knowledge of engineering topics?
4. What effect, if any, has participation in ENGR 2101 had on your professional knowledge? (soft skills)
5. Do you feel that participations in ENGR 2101 influenced on your interest to major in engineering? Why or why not?
6. Do you feel that participations in ENGR 2101 influenced on your persistence towards your engineering major? Why or why not?
7. How do you define service-learning?
8. Do you see ENGR 2101 as a service-learning course? Why or why not?