Students' Feedback About Their Experiences in EPICS Using Natural Language Processing

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***Abstract*— This research full paper presents research around the Engineering Projects in Community Service (EPICS) program that serves two key purposes to: 1) provide a structured approach for engineering students to engage in real-world, service-based projects and 2) provide technical support and expertise that may be critical to local and global community organizations. Hence, EPICS strives to offer a platform that fosters the collaboration of engineering students and communities. EPICS helps develop undergraduate students' professional skills extending beyond the theoretical knowledge acquired in classrooms. EPICS has been a fixture in engineering education for over 15 years, with a strong focus on curricular and pedagogical interventions to help students gain professional skills. The purpose of this paper is to explore the perspectives of over 650 students who participated in EPICS at a U.S. university during the academic years of 2019/2020 and 2020/2021. We used natural language processing (NLP) to thematically analyze students' responses to an open-ended survey administered at the end of their semester participating in the EPICS program. Students' responses reflect their perspectives on the design process, teamwork, real-world experiences, and the challenges they face during the design process related to other people and the program. In our findings, students' least favorite parts of EPICS were lectures and design reviews, while their favorite parts of EPICS were teamwork and engaging with community partners. Understanding the themes emerging from the data can help us better implement community-based educational initiatives and find ways to better engage students in community service-learning projects. Our research provides implications for practice and research.**

Keywords—service learning, student experience, EPICS, natural language processing

I. Introduction

EPICS was founded at Purdue University in Fall 1995 [1]. It provides a project-based service-learning experience in multidisciplinary settings. More than 30 universities have adopted it through their curricula [2]. EPICS has been applied successfully in these institutions by providing long-term community partnerships and adequate impact on society [3]. Programs expect students to learn: "discipline knowledge, lifelong learning, client awareness, communication, ethics, broader context, entrepreneurial mindset, multidisciplinary design, service learning, professional preparation, and social entrepreneurship" [4]. These skills and knowledge are essential to develop and maintain a long-term relationship between project teams and community partners where students experience various responsibilities due to society's complex needs and growing technology. EPICS projects have become a bridge between the community and universities to collaborate and find individualized solutions. These multidisciplinary, diverse, community-oriented projects bring broader impacts to communities locally and internationally. Therefore, they are unique settings for most institutions' experiential learning and design processes in their engineering curricula.

Accreditation organizations such as the Accreditation Board for Engineering and Technology (ABET) set criteria for accreditation for engineering programs. They define the purpose of the engineering design process, what it is and what it involves [5]. EPICS is different from other design course settings (i.e. first-year design courses, and senior design courses) since it provides community connections and helps form teams with diverse backgrounds from multiple disciplines. It is an elective course in which students can choose to stay on a project for multiple years or participate in multiple projects in sequence. In contrast, first-year and senior design projects are usually offered/required for one to two semesters.

EPICS structures meet the requirements of program and student outcomes [6]. For example, the objectives of EPICS courses meet the requirements of ABET's Criterion 3 student outcome (3.1-3.7) [5]. Criterion 3.1 specifies the importance of "an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics" [5]. EPICS meets this criterion while students identify the issues and needs of community partners and apply their discipline knowledge [4]. In addition, Criterion 3.3 emphasizes "an ability to communicate effectively with a range of audiences" [5]. EPICS teams include many stakeholders such as students, professionals, graduate students, faculty members, and community partners from diverse backgrounds. Having

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such team settings helps students improve their professional and technical communication skills while identifying the needs of community partners, attending regular project meetings, and presenting their projects. Students can have unique experiences in real-world engineering applications in EPICS during design processes, team meetings, and project management. Student experiences in EPICS meet ABET requirements [7].

EPICS helps develop undergraduate students' professional skills extending beyond the theoretical knowledge acquired in classrooms. Engineering students benefit from it in a unique way that aligns with the competencies required by industry that may be difficult to promote in a traditional classroom. EPICS involves professionals and students having different levels of project experience. We acknowledge that the experiences of professionals, community partners, and non-engineering students in EPICS might be different from the findings we present in this paper. This study only focuses on undergraduate engineering students' experiences. These students have a central role in EPICS projects. Their abilities and experience levels might differ across their class standing and engineering discipline, bringing various challenges to each individual. However, students may find common tasks more challenging or fun during their projects.

Students' feedback about their experiences in EPICS can give us an idea of those challenging experiences and things they enjoy doing the most. In this study, we examine students' experiences by exploring the least favorite and favorite parts of EPICS for students from various engineering disciplines. The specific research questions are:

RQ1: What are the least favorite parts of EPICS for engineering students?

RQ2: What are the favorite parts of EPICS for engineering students?

The following sections introduce service learning and EPICS, present thematic analysis with the NLP approach, our findings, discussion, and conclusion.

II. Service Learning

In our study, we viewed service learning as one of the learning models of experiential learning. Service learning models expand curricula outside of classrooms and connect students with communities [8]. Serving communities encourage students to apply the knowledge they learn in classrooms to make positive changes in people's lives [9]. In previous literature, researchers stated that Dewey fostered service learning in [10], and their philosophy led to service learning's theoretical foundation [8], [11], [12]. Dewey embraced the importance of experience and learning beyond the classrooms for democratic society that is essential for communities [9], [10]. Dewey supported active learning for students to bring their knowledge together to create ideas and their concern was about students lack of abilities to connect their knowledge with their ideas because of the traditional education in classrooms [10], [11] Waterman stated that Dewey considered community as an essential element of students' experience during their formal education and personal and professional development [9].

During the development of the theoretical foundation of experiential learning, Kolb expanded on Dewey's philosophy in the 1980s [8]. Kolb highlighted the growing gap between the passive learning outcomes and required skills for engineering and proposed and grounded experiential learning to close this gap [13]. In experiential learning theory, Kolb stated that learning occurs when knowledge is gained during an experience and transferred to other similar experiences [13]. The transfer of knowledge to new experiences has several key steps including reflection, conceptualization, and testing of experiences that embrace the learning process [8]. In our study, we considered reflection in Kolb's experiential learning theory as students reflected on their experiences in their responses, which led us to learn more about their experience in service-learning.

A. Service Learning and EPICS in Engineering Education

Engineering offers insights for improving the quality of life for humankind through problem-solving initiatives that are critical for addressing societal challenges [14]. ABET also emphasizes that engineering students should have the capacity to solve complex societal problems as part of the learning outcomes [5]. Through curricula reforms, institutions and programs have adapted service learning to expose engineering students to gain the practical ingenuity needed for the engineers of 2020 [14]. Service-learning enhances student learning through community involvement as part of experiential education [15]. Service-learning balances the student learning through an activity that is of service to the community and the academic content of the student learning [16]. Although service-learning offers relevance in engineering education for the 21st century, there is no commonly agreed-upon pedagogical framework for meeting the standards established by NAE and ABET [16]. EPICS has been established as a quintessential model for bridging this gap.

The EPICS approach integrates engineering design to meet the local community's needs through a multidisciplinary service-learning curriculum [15]. Accordingly, Gillespie et al. contend that EPICS differs from a traditional service-learning program in many ways, considering that the EPICS model situates students in communities with real community partners to enhance student learning [17]. Through the EPICS program, students "solve complex and compelling problems in the community that do not fit within the traditional academic term" [18, p. 45]. EPICS has been established as a promising endeavor in engineering education in terms of specific skills' set development, student learning, and students' preparation by several researchers [16]–[20]. Notably, EPICS offers a relevant "curricular model to prepare students for [various] careers including those within traditional corporate engineering settings. It has also been shown to be a means to develop and sustain long-term community partnerships that provide mutual benefit and significant community impact" [3, p. 27]. However, little is known about the perspectives of undergraduate engineering students who experience these programs. Therefore, as EPICS evolves, Zoltowski and Oakes [3] also suggest that programs and institutions should systematically integrate new interventions and outcomes into their programs to enhance students' learning and impact communities.

B. Student Experiences and Outcomes in EPICS

In the EPICS experiences, engineering students "learn design while they develop designed products for local or global community partners" [16, p. 5]. As EPICS programs experience monumental growth, the program's main objectives for students' experience are preparing them for professional practice and enabling them to be responsive to human and community needs [21]. To gauge the effectiveness and outcomes of students, institutions have implemented several assessments of the EPICS program, such as attending lectures, design reviews, and documentation [3]. Furthermore, some key assessment areas include individual student learning, grading, student teams, and project assessment [21]. Notably, assessment trends have revealed that students gained critical skills, such as technical skills (i.e., programming, design process) and professional skills (i.e., teamwork, leadership, communication, and project management) [3], [21], [22]. Students also demonstrated value for design concepts and human-centered design approaches gained through EPICS with an appreciation for workplace preparation [3], [18].

There is evidence indicating the impact of EPICS on certain learning outcomes may have decreased. A recent analysis of the EPICS program at Purdue University showed a reduction in organizational and project management skills development [21]. Although students reported developing teamwork and leadership skills less than before [3], [21], these skills still remain relevant in the experience of most students who participate in EPICS [21]. According to Zoltowski and Oakes, the decline in developing teamwork skills through EPICS is due to the recent focus on formal team-based learning starting from first-year engineering education [3]. Additionally, students exemplified a substantial benefit of participating in multidisciplinary teams with more diverse student populations [21]. Although another study by Gillespie and colleagues [17] found multidisciplinary teams were not a major advantage in students' experience, teamwork helps students obtain knowledge of "engineering and innovation, not only in project design and planning but also human-centered design skills" [19, p. 71]. While working in multidisciplinary teams is a goal of EPICS [17], it provides a framework for developing students into holistic engineers through the learning of professional and technical skills [16]. Supporting multidisciplinarity in teams enforces collaboration, communication, and leadership skills and empowers students to develop transferable skills for academia and industry [17].

III. METHODS

To answer the research questions, we used a text clustering natural language processing (NLP) approach to analyze end-of-semester survey responses from students participating in EPICS. This method builds on recent developments in language models using transformer architectures [23]. The specific model was developed previously for analyzing student feedback responses to a first-year engineering course [24]. The basic mechanism is to take the raw text from students' responses to the survey, use the pre-trained models to create a numerical representation of these responses by embedding them in a high-dimensional vector space, and cluster similar responses together using agglomerative clustering. Ultimately, this process identifies semantically similar student responses. In the final step, members of the research team then manually analyze the clusters to label them based on their themes.

A. Research Site

The research was conducted at a southwest research university in the U.S that integrated EPICS into their engineering, design, education, and business programs' curricula in Fall 2009 [25]. The EPICS program includes engineering students from all the engineering disciplines regardless of their year in the college. This program eventually became the largest social entrepreneurship program within the university [25]. EPICS projects aim to provide environmentally friendly solutions by focusing on the needs of the community partners. They categorized the projects under four themes: sustainability, community health, education, and health [26]. Individual projects based on the requirements of community partners are assessed to impact international and domestic communities while students experience real-world engineering applications.

EPICS has been offered as a sequence of one-credit courses with students enrolled in at least one year. Students choose a project under one of the four themes each semester and can stay on the same project for multiple semesters or change their project choice after each semester. Students learn to work as a team and develop project and budget management skills in real-world problems. Projects teams consist of 4 to 10 students from various disciplines and are formed based on students' schedules fitting with team meeting time slots, project interests, class standing, major, experience, and skills [17]. Each project team is matched with professionals based on their expertise relevant to projects. EPICS is an impactful ongoing project program where students develop several professional and soft skills. They experience applying their disciplines' knowledge to the design process based on their community partners' needs [4]. Moreover, students work with diverse multidisciplinary backgrounds that improve their communication and presentation skills. The outcomes of successful projects meet community partners' requirements, and students can see how their abilities and knowledge play a role in broader contexts.

a) EPICS Course Structure: Only first-semester EPICS students are required to attend a 50-minute weekly lecture component (in addition to weekly team meetings). The additional lecture component is designed to introduce new EPICS students to 1) the course itself including structure, key activities, and assignments, 2) the EPICS engineering design process (see Fig. 1), and 3) professional skills such as project management, communication, and teamwork. The first two weeks of the lecture component include high-level information about the program including overall expectations and goals, course structure and schedule, how to navigate the Canvas page, an overview of class assignments and grading, and an introduction to an engineering design process. Students are also provided instruction on how to join a new or existing team connected to a real-world service project. The course then transitions to providing pertinent information in a timely manner that can aid new students in navigating their projects. This includes introducing students to the EPICS engineering design process to help scaffold and provide structure on how to approach their projects. The EPICS engineering design process was mirrored from Purdue's EPICS Design Process and includes the following stages: project identification, specification development, conceptual design, detailed design, delivery, service maintenance, and retirement [27].

Within these design process stages, various tools and approaches are presented to students such as how to conduct a needs assessment, develop customer requirements, model a problem, brainstorm, evaluate ideas, make decisions, prototype, field test a prototype, consider ethical implications of their projects, assess impact, etc. Case study examples from previous EPICS teams are frequently used to help illustrate how various tools and approaches can be applied to specific contexts. Throughout the semester students are also introduced and given clear expectations on key assignments including the design document, design review presentations, and CATME self and peer evaluations. For example, students are expected to maintain detailed documentation of their design process and decisions in their team design document.

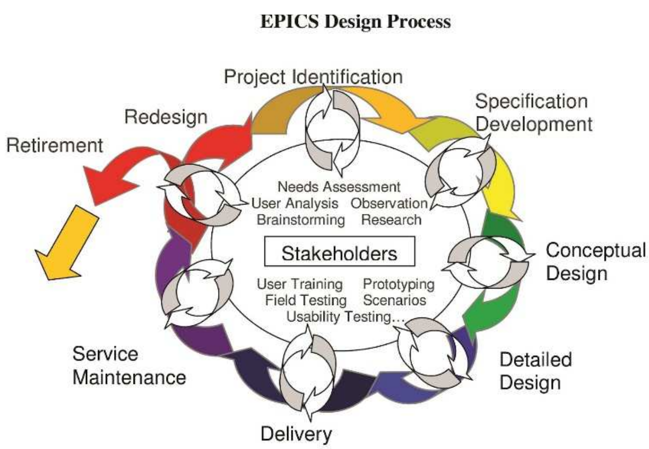

Fig. 1. EPICS design process taken from Purdue University EPICS program [27].

Each EPICS team is responsible for participating in two design reviews each semester to a panel of industry/academic experts, community partners or stakeholders, and/or EPICS faculty and staff. The design reviews enable student teams to formally present their project progress, design process, and technical design. The presentations are typically 10 minutes and are followed by questions and feedback from the panel members. Design reviews are intended to have students practice their technical communication skills and also obtain important feedback that can be applied to their service project. Finally, students are also introduced to various professional skills such as project management, design documentation, writing professional emails, providing/receiving peer feedback, and how to communicate their EPICS project and experience. Although it is called a lecture component, various active-learning pedagogies are used (i.e.., think-pair-share, class activities to practice tools) to help engage students with the content.

B. Data Collection

End-of-semester surveys were conducted in an EPICS course in Fall 2019, Spring 2020, Fall 2020, and Spring 2021. Due to the COVID pandemic, the Fall 2020 and Spring 2021 EPICS courses offered via Zoom and the Spring 2020 course offerings were transitioned from in-person to Zoom approximately halfway in the semester after spring break. Although students primarily convened over Zoom in the Fall 2020 and Spring 2021 semesters, the prototyping spaces were available for reservation during in-class weekly team meetings. Several students and teams did utilize these spaces to advance their prototypes, but in general most students and teams regularly met online for weekly class meetings. The course was taken by engineering students regardless of their year in the college. The participants varied from first-year to 5+ year students in civil, chemical, electrical, mechanical, industrial, aerospace engineering, material science engineering, computer science, and other disciplines. For this study, only two open-ended questions responses were analyzed. The questions students were asked to answer were "What was your least favorite part about EPICS?" and "What was your favorite part about EPICS?". A total number of 650 students responded to the survey questions.

C. Data Analysis

We used an NLP-based approach due to a large number of responses. Our computer-assisted, human-in-the-loop process allowed us to save time when compared with manual coding for thematic analysis [24]. We started with cleaning the raw data from the surveys, removing non-responses for specific questions. Next, we merged the raw data collected in four semesters. For this particular study, we focused on responses to only two questions on the end-of-semester survey. The responses with more than one sentence were split into single sentence entries. Doing so allowed us to identify multiple topics in student responses when they mentioned different things they did and did not like about their EPICS experience.

After preparing the data for analysis, these split sentences were embedded into a high-dimensional vector space using the RoBERTa pre-trained language model [23]. This embedding process generates an abstract numerical representation of each sentence in the 1,024-dimensional embedding space. After embedding sentences, the next step was dimension reduction by applying both linear and nonlinear dimensionality reduction processes. The first step was using principal component analysis (PCA) to reduce the dimensions of embeddings from 1,024 dimensions to 90 dimensions. This step balances maintaining the variance in the original data while getting closer to a lower-dimensional representation of the text to enable a clustering step [24]. Before the clustering, however, a second dimension reduction step was applied using uniform manifold approximation and project (UMAP). This reduced the representations from 90 dimensions to five dimensions [28]. In this final lower dimensional space, our data were ready to cluster. As a final step, we chose the agglomerative algorithm to cluster the data because a previous study showed that this method generated the most homogenous clusters compared to alternative clustering methods such as k-means and other hierarchical methods.

After generating clusters of responses for both datasets, one of the researchers read through each cluster manually (the human-in-the-loop part of this process) and checked if the sentences had similar meanings. Also, the researcher eliminated low-information clusters such as the clusters that were created based on the terms “no answer provided,” “none,” “nothing,” and “EPICS.” In the next step, the researcher merged some of the clusters with the same themes but clustered separately by the algorithm. Ultimately, this process identified themes in students’ responses and which responses belonged to which theme. During the process of identifying the themes, we allowed each student’s response to count only once per theme to avoid overcounting if a response used more than one sentence to explain the same theme.

IV. Findings

Student responses for the least favorite parts in EPICS and favorite parts in EPICS were analyzed separately with the NLP approach. This section presents the results for the themes that emerged from responses to both survey questions.

A. The Least Favorite Part of EPICS for Students

Initially, the computer-assisted NLP approach generated 27 clusters from the responses about the least favorite parts in EPICS. Manually coding for themes was done for these 27 initial clusters. Six clusters were meaningless or unnecessary and excluded during the manual coding process. Those six clusters were generated based on the responses that included “no answer provided,” “nothing,” “none,” “the least favorite…”, and “loved it all.” The researcher merged some of the clusters into one theme because of the similar contents. At the end of the manual thematic analysis from clusters, we had 14 themes from student responses. A total number of 468 sentences were included in the themes. Since we split responses into sentences, some students’ responses were counted multiple times in a theme. To avoid this, we only counted their responses once for each theme. Thus, in the end, we had a total number of 454 sentences included in our thematic analysis. Fig. 2 shows the distribution of these 14 themes on the least favorite parts of EPICS. The count of sentences represents the number of sentences that were clustered under each theme. As shown in the figure, lectures were the least favorite part of EPICS mentioned by students.

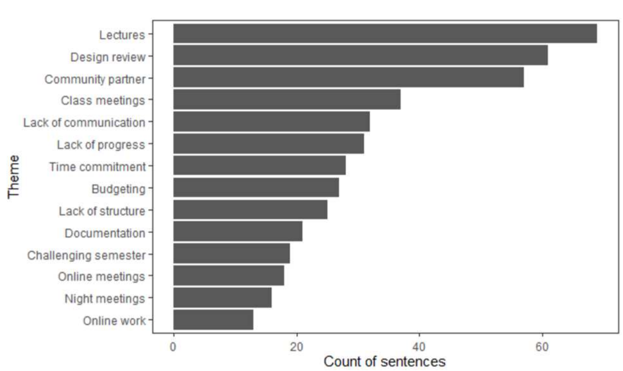

Fig. 2. The distribution of the least favorite part of EPICS.

These fourteen themes and example comments from students’ responses are shown in Table 1. Most students mentioned the lectures were boring and repetitive. They also were not happy with the scheduled lecture time during the semester. Some of the students said they did not like the lectures without giving specific reasons. The second least favorite part of EPICS was the design review for students. Students were not satisfied with the feedback they received in their design reviews, and they thought that expectations were not clearly defined earlier, so they had mixed feedback at the end. In additional topics, students complained about a lack of communication and lack of received feedback from community partners. Class meetings were another theme that students needed longer and more sessions. The rest of the themes can be seen with highlighted examples from student responses in Table 1.

TABLE I. Themes for The Least Favorite Part of EPICS

Theme	Examples from the Responses of the Participants
Lectures	• I did not like the lecture part. • The lectures were sometimes hard to pay attention to/ boring if I had to be honest.
Design review	• I do wish that the scope and expectations of our project were more clearly defined. • There seems to be no standard for the feedback portion of the Design Review, which is understandable, but the feedback we got was a very mixed bag.
Community partner	• Poor communication from community partner. • The beginning of EPICS was a little rough, the teams had trouble getting in contact with their community partners and people were dropping in and out of groups.
Class meetings	• The class is getting too big, I believe more sessions or bigger spaces should be used for teams to properly communicate and work. • I wish I would've had more designated class time to work on my part of the project, it often times felt like a lot of work for a 1 credit class
Lack of communication	• Difficulties in communication • Lack of communication from community partner
Lack of progress	• Since the projects are very open-ended, the lack of specific direction or instructions was difficult at times • Big gaps of time with little progress
Time commitment	• The lack of overall time the team dedicated to the project. • Time commitment.
Budgeting	• Funding is really hard to get. • Budget always takes a very long time.
Lack of structure	• Not having a clearly defined way to approach our problem. • Lack of structure.
Documentation	• Multiple design document submissions. • The Design Review/ Design Document.
Challenging semester	• Nothing specific to EPICS, just the limitations due to the circumstances of this semester and COVID-19. • The shortness of the semester.
Online meetings	• Communication is really frustrating over zoom (but that was out of your control). • Zoom meetings weren't the most fun, but they obviously were the only way to meet.
Night meetings	• Meetings happened at night. • Having to stay at school late on Wednesdays.
Online work	• The online work environment. • The whole quarantine/switch to online thing.

The distributions of themes were broken into their class standings and students' majors shown in Fig. A1 and Fig. A2 in Appendix A, respectively. The largest number of students who responded to the question were first-year students, and their least favorite part was the lectures. Looking across disciplines, mechanical engineering students answered with the largest number of responses, and they identified design review as their least favorite part of EPICS. However, we thought the number of sentences analyzed for each discipline and class standing may not be representative. Therefore, we preferred to provide them in the Appendix rather than interpreting them for these specific groups of people.

B. The Favorite Part of EPICS for Students

Students were asked to identify their favorite part about EPICS. Before manual coding, the NLP approach generated 26 clusters from students' responses. During the manual coding, four of the clusters were generated based on the terms "no answer provided," "my favorite part...", "I enjoyed….", and these clusters were removed. Some of the clusters were merged into one theme because of the similarities. In the end, student responses were classified into 16 themes. A total number of 507 sentences were included in these 16 themes. Since we split responses into sentences, some students' responses were counted multiple times in a theme. To avoid this we only counted their responses once for each theme. In the end, we only excluded three sentences. Fig. 3 shows the distribution of these 16 themes in the favorite parts of EPICS.

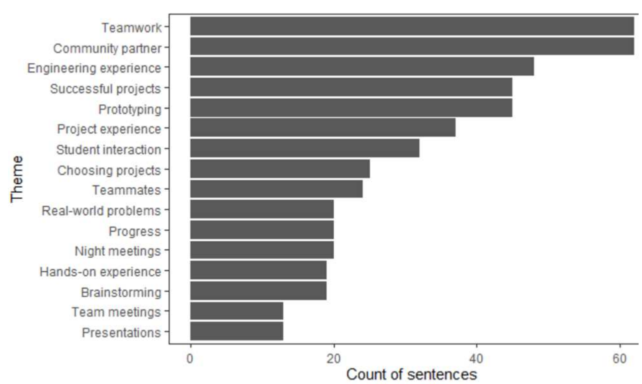

Fig. 3. The distribution of the favorite part of EPICS

Teamwork and community partners were equally mentioned with the highest number of sentences. Students emphasized they enjoyed working with a team. They liked the involvement of community partners. Students were satisfied with their community partners' direct communication with them. Students also mentioned that they had engineering experience working with fellow engineers closely. Another theme was successful projects that students mentioned in their responses. Along those lines, they liked to show off their accomplishments. These 16 themes and examples of students' responses for each theme are presented in Table 2.

The distributions of themes for favorite part of EPICS were broken into their class standings and students' majors shown in Fig. B1, and Fig. B2 in Appendix B. Similar to the question about least favorite parts, mechanical engineering students responded to the question the most, and their favorite part of EPICS had teamwork. Across class standing, the largest number of students who responded to the question were freshmen, with most of them saying working with community partners was their favorite part of EPICS.

TABLE II. THEMES FOR THE FAVORITE PART OF EPICS

Theme	Examples from the Responses of the Participants
Teamwork	• Working with my team to bring our project together. • Being able to work in a team and use the many tools to build something.
Community partner connections/ meetings	• The involvement with the community. • …having a community partner that responded to emails and was in direct contact with us.
Engineering experience	• Putting the engineering knowledge to work. • Getting to meet fellow engineers and working closely with them for a semester.
Successful projects	• I love how we can show off our work and what we've accomplished…
Prototyping	• Working on our prototype and planning the experiment to test it. • Building models of our design.
Project experience	• Working on a project that I am passionate about and invested. • Great project experience.
Student interaction	• Networking with students. • I got to interact with my peers.
Choosing projects	• Selection of projects. • Control of project's direction.
Real-world problems	• Solving a real world problem. • The collaboration and that I was working on a REAL project to help REAL people with a REAL solution!
Progress	• Getting to work on and see an tangible progress in a project. • Seeing progress toward our project goal.
Night meetings	• I liked the nightly team meetings. • The nightly meetings to work with my team on a project.
Hands-on experience	• Communication is really frustrating over zoom (but that was out of your control). • Zoom meetings weren't the most fun, but they obviously were the only way to meet.
Brainstorming	• ...[it] allows you to brainstorm ideas based on the presentations. • Brainstorming solutions to a problem.
Teammates	• Joining a group of people that have a desire to work as a team on a unified goal. • The people in my group.
Team meetings	• Meeting with the team. • The team meetings.
Presentations	• Working on a team and giving presentations. • The group presentations and pitching.

V. LIMITATIONS

There are contextual and methodological limitations in this study. This study focused on engineering students' experiences in EPICS, and the findings were discussed only for engineering students. We acknowledge that non-engineering students might experience EPICS differently. However, this study's findings can not be generalized to all undergraduate students. Also, we did not consider if students who participated in our survey had taken previous design courses or had contributed to any EPICS team before. Thus, we can not interpret the relationship between students' previous design experience and their feedback in this study. In addition, as with much survey-based research, we did not know how seriously students took the survey while they were participating, so we assumed the responses were sincere and reflected the actual experience. On another note, some data were collected before the pandemic (COVID-19) and some of them during the pandemic. The immediate change in the course modality might have affected the students' experiences and feedback. Finally, the method we used might misclassify the responses due to the algorithm and the number of respondents. However, it still gave us an idea about what engineering students think about their experiences in EPICS and happened little in practice since the human in the loop played a role in mitigating this potential problem.

VI. Discussion

The two least favorite parts of EPICS were the lectures and design reviews. Traditional lectures are part of the EPICS course, where students tend to learn technical skills [3]. In a survey at another university that offers EPICS, students found the lecture contents of EPICS were relevant to the course [21]. Some students in this study indicated the lecture content was relevant as well. However, they mentioned the lectures' time and the repetitive content. Only students who are new to EPICS (enrolled in a specific course number for EPICS) are required to attend lectures. There might be various reasons why students may not enjoy the lecture component. One reason may be that it has some overlap with an introduction to engineering course offered at the university that is required for all engineering students in their first-year. In this introductory course students are also taught an engineering design process that likely has some similarities to the EPICS framework. From the collected data the highest number of responses came from the first-year students (see Figure A1 in Appendix A) and they mentioned lectures the most as their least favorite part of EPICS. Many of these students are also taking the introduction to engineering course in the same year, which aligns with our interpretation. Another factor negatively impacting students' impression of the lecture component may have to do with the transition from an in-person class to an online format during the pandemic. This may have impacted engagement and interest in the 50-minute lecture component. These reasons might be why students think lectures are the least favorite part of EPICS. Another university provides recorded lectures as supportive resources [21]. While students may not necessarily enjoy the lecture component, it is essential that students are properly introduced to the program and to the expectations of the course. Other formats should be considered in relaying pertinent information to students such as an online format in which students can watch recorded content and complete self-directed assignments, reflections, and/or quizzes to ensure they have the prerequisite knowledge and skills to effectively contribute to their projects. Also, the structure and pedagogy of lectures for EPICS can be further investigated to understand what makes them the least favorite part of EPICS for students.

Other students in different years of their studies mentioned design reviews and lack of progress as their least favorite part of EPICS. Design reviews are one of the assessment artifacts for EPICS [3]. Each team prepares design review documentation and presents on their projects twice a semester. Professionals relevant to the projects give feedback to the project teams to improve teams' design and address solutions for project issues. In this study, the second least favorite part of EPICS for students was design reviews. They mentioned the lack of instruction for design reviews and expectations from these presentations. Also, some students emphasized that feedback from the reviewers was not clear. Based on the findings of this study, we recommend that institutions consider providing more information about what is expected from design review presentations.

The two favorite parts of EPICS were teamwork and engaging with community partners. Coyle et al. stated that most students improve their teamwork skills during the projects in EPICS [22]. In this study, several students mentioned working as a team is their favorite part of EPICS. Students indicated positive views on their developed teamwork skills. The second favorite part of EPICS is direct engagement with community partners. Both students and community partners benefit from the projects in EPICS, and project teams regularly communicate with community partners through the project design and implementation [3]. When students have a strong relationship with community partners their motivation increases and this leads students to feel responsible to the community [29]. Understanding community partners' needs and receiving feedback are essential for projects' progress. Developing the partnership between students and community partners to provide technical support and expertise may be critical to projects for communities. On the other hand, community partners were mentioned as the third least favorite part of EPICS. It demonstrates that finding reliable, supportive, and communicative community partners is essential to the EPICS experience. Faculty should closely monitor communication experiences with community partners in experiential learning experiences like EPICS. This is consistent with Darby et al. finding that a lack of communication with community partners decreases student motivation which is essential for student learning and experiences [29]. Overall, understanding students' experiences is vital for implementing educational initiatives and finding ways to improve their learning and experiences in EPICS.

VII. Conclusion

We thematically analyzed the students' feedback on the least favorite and favorite parts of their experiential learning concept EPICS. Students' reflections on their experiences in EPICS may help instructors, administrators and community partners understand what are the areas, tasks, etc. students have difficulties with or enjoy doing while contributing to projects in their experiential learning cycle. Students' success, effort, and motivation can affect the experience of each stakeholder involved in the experiential learning process since students are the major doers in community projects. Therefore, we believe that it is critical to understand students' reflections on their experiences to develop better opportunities that students can bring their theoretical knowledge into practice and transform their experiences. Professionals may further improve their EPICS curricula and practice to enhance students' learning and participation and experiences that would lead to the improvement of knowledge in communities.

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Appendix A

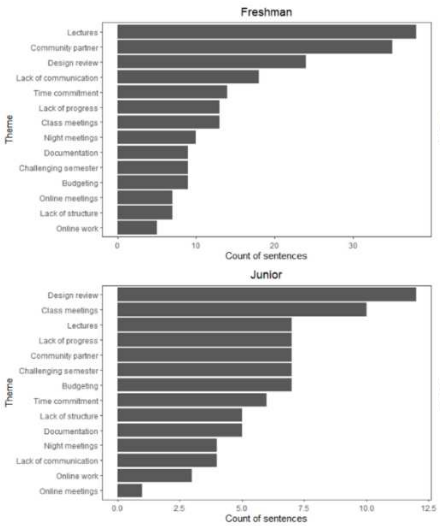

Fig. A1. The least favorite part of EPICS by class standing

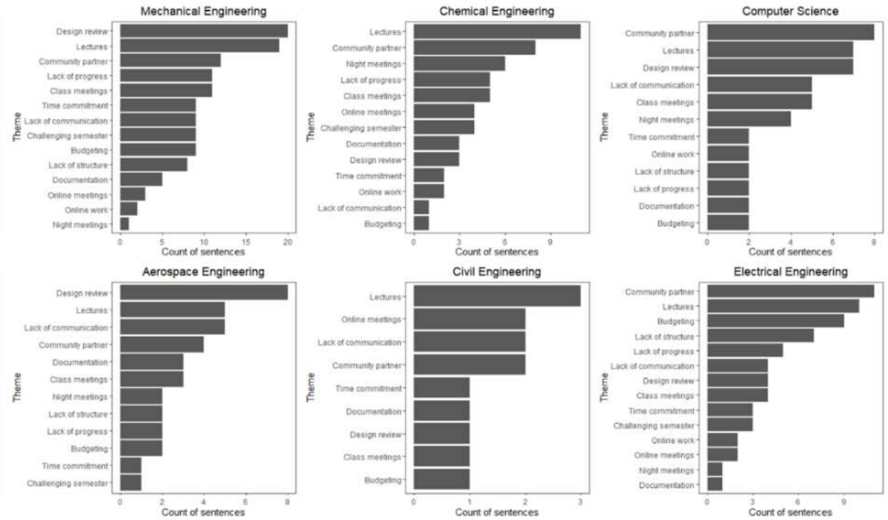

Fig A2. The least favorite part of EPICS by majors

Appendix B

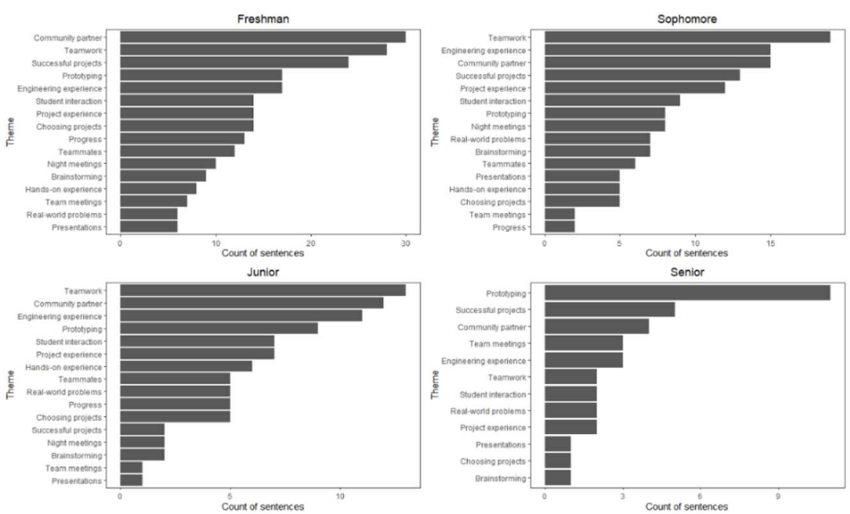

Fig. B1. The favorite part of EPICS by class standing

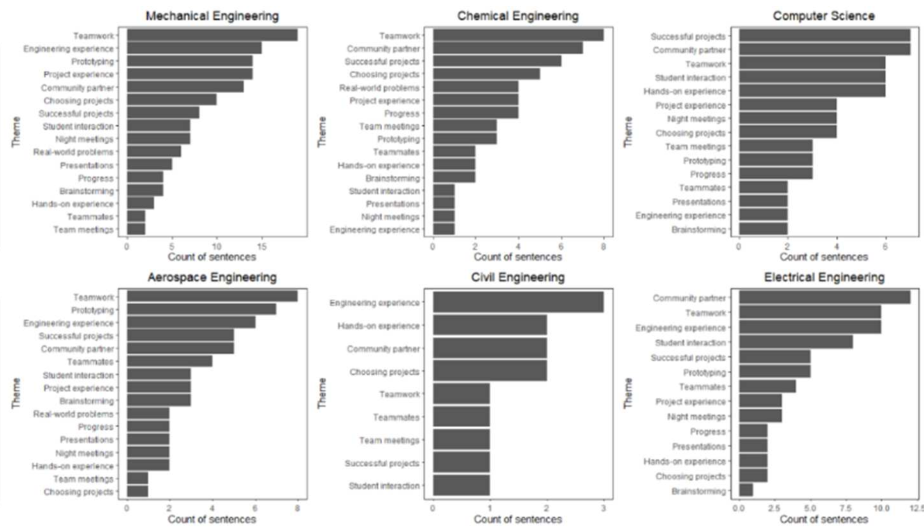

Fig. B2. The favorite part of EPICS by majors