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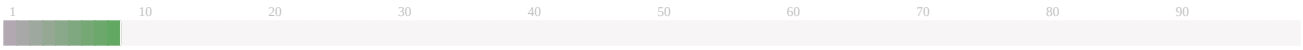

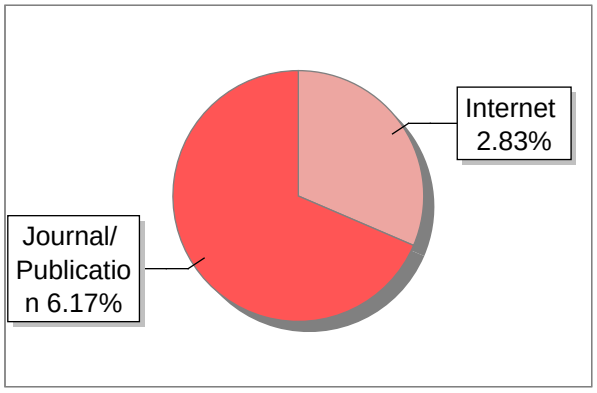

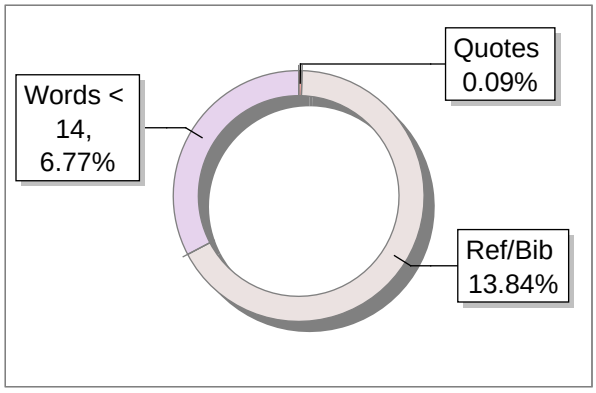

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Involving Engineering Student in Community-Based Project: A Qualitative Study

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Introduction

International engineering education standards require a well-rounded graduate profile that extends beyond theoretical ability, encompassing a basic foundation in science, mathematics, and specialized engineering subjects (Charosky et al., 2022). Beyond theoretical knowledge, engineering graduates must be able to use a variety of contextual knowledge to address various social issues and responsibilities relevant to professional engineering practice; hence, be able to provide solutions to complex engineering problems (International Engineering Alliance, 2013). Concurrently, these standards also require several competencies needed in the future, such as creativity, innovativeness, problem-based thinking, collaboration, communication skills, and agility in uncertainty (Charosky et al., 2022). Given the history of engineering involvement in sustainable development, these requirements are very reasonable (Chen et al., 2020); engineering has evolved into an essential part

in addressing the needs of the community (International Engineering Alliance, 2013), while also being an innovation driver.

Unfortunately, to date, the gap between engineering education and community remains a subject of ongoing discussion and research (Charosky et al., 2022). Engineering graduates struggle to adjust to the practical working environment since the industry perceives them as "too theoretical" (Charosky et al., 2022). In addition, many universities are currently focusing on technical and research skills, inadvertently leading to deficiencies in practical experience when engaging with the community (Guo et al., 2020). Specifically in the context of engineering faculty, previous research showed that engineering graduates lack community involvement among academic programs after graduation (Chittum & Finley, 2022).

Various research has been conducted to explore the appropriate educational approaches and processes to meet demands while eliminating gaps that occur, namely problem-based learning, project-based learning, innovation pedagogy, community-based learning, community-based research (Charosky et al., 2022; Goggins & Hajdukiewicz, 2022; Guo et al., 2020; Mebert et al., 2020; Mello-Goldner, 2019). As an example, in order to address the gap between theoretical and professional skills, problem-based learning or project-based learning approaches are widely implemented in education. Project-based learning is an inquiry-based educational strategy that involves learners in knowledge production by assigning relevant projects and requiring them to create real-world results (Guo et al., 2020). This approach is quite similar to problem-based learning, with the key distinction being its incorporation of artifact production as a requirement. The process of creating artifact requires learners to work together to find solutions to authentic problems, fostering the integration, application, and construction of knowledge throughout the process. (Guo et al., 2020). This approach shows positive results across the cognitive, affective, behavioral, and produced artifact aspects (Guo et al., 2020).

Other approaches employed to bridge the gap between education and community needs include community-based learning, community-engaged learning, and community-based research (Chen et al., 2020; Goggins & Hajdukiewicz, 2022; Mello-Goldner, 2019; Strand, 2000). These similar concepts allow students to express themselves, develop, and solve communities' inherent problems or concerns. A recent study has indicated that introducing community-engaged learning into an

engineering undergraduate program serves as a highly effective mean to fulfill the Washington Accord program requirement. The introduction offers the students a comprehensive understanding of the role of engineering in the community and the identified issues in engineering practice. Furthermore, it incorporates an exploration of the impacts of engineering activity in economic, social, cultural, environmental, and sustainability (Goggins & Hajdukiewicz, 2022).

In the context of Indonesia, in line with the international engineering educational standards, Indonesian standards set by IABEE (Indonesian Accreditation Board for Engineering Education) oblige engineering graduates to possess both proficient engineering skills and a sense of responsibility toward society in solving engineering problems. Moreover, the standard necessitates the inclusion of mandatory training and courses, culminating in a major design project. The mandatory training and courses will provide opportunities for students to integrate knowledge and skills acquired in their preceding coursework (Indonesian Accreditation Board for Engineering Education, 2020). This course implements a project-based learning approach, allowing students to cultivate practical technical skills by combining theoretical understanding with hands-on experience along with other relevant knowledge and skills (Indonesian Accreditation Board for Engineering Education, 2020). Additionally, the standard mandates that students must produce an artifact or product. This kind of project-based course effectively bridges the gap between industry requirements and the competence of engineering graduates. The project-based course also plays an important role in developing key innovation competence to address current societal challenges (Charosky et al., 2022).

Interestingly, throughout the implementation of culmination project, two types of student projects emerge: those that generate artifacts without targeting specific users, and those that produce artifacts directly utilized by stakeholders or the community. The second type of student project surpasses the educational standard's expectation by implementing community values. If the second type of student project presents more favorable outcomes than the preceding one, we identify an opportunity to improve the design of the student project in the future. Previous research shows that involving these values in student learning increased motivation (Goggins & Hajdukiewicz, 2022) and awareness of the importance of addressing each party's concerns, interests, and needs (Ross et al., 2010).

Previous studies have explained the benefits of community-based projects implementation for students and institutions (Arantes do Amaral & Lino dos Santos, 2018); however, more literature is

needed to explain how this process works(Guo et al., 2020; Ochocka & Janzen, 2014; Tijsma et al., 2020). Most of the studies were conducted in the health sciences (Abraham & Torner, 2021; Dean et al., 2023; Gimpel et al., 2018; Karasik, 2020; Kristina et al., 2018; Meidianawaty et al., 2016) and social sciences (Case, 2014; O'Brien & Sarkis, 2014; Strand, 2000), nevertheless limited study show implementation in the engineering field (Chen et al., 2020; Goggins & Hajdukiewicz, 2022; Mebert et al., 2020). Moreover, in Indonesian research publication, we found limited discussion about this learning strategy(Kristina et al., 2018; Meidianawaty et al., 2016; Syamsi & Heriyanti, 2022). We believe understanding the processes and student experiences will lead to insight into community-based-final project designs in engineering. Therefore, this study intends to explore students' experience in engineering community-based projects that have never been carried out in published research in Indonesia. Based on this, we formulated two research questions in this study. First, how are the processes of community-based project implementation? Second, what experiences do students gain while implementing community-based projects, including their feelings and values?

Method

The research applied phenomenology framework to inquire experience of engineering student with their community-based project. First applied to social science by Edmund H Husserl, this tradition study how people describe things and experience them through their senses (Patton, 2014).

Participants

We collaborate with two IABEE-accredited engineering programs that have implemented community-based projects in some of their students' final projects over the past two years. We applied purposive sampling by announcing opportunities to students who had implemented community-based projects. The sampling technique is widely used in qualitative studies by identifying and selecting individuals who experienced a phenomenon of interest (Palinkas et al., 2015). Thirty-nine participants were involved in this study and expressed their availability and willingness through the informed consent stated at the beginning before filling out the survey. The participants were graduates and students of engineering programs (Table 1). Subsequently, three participants who expressed their availability and willingness to be interviewed underwent an interview session to elaborate on deeper information.

Table 1

Participants and educational background

Study Program	Number of Graduates	Number of Students
Electrical Engineering	4	18
Mechanical Engineering	0	17

All participants have completed their final project, which involved engagement with the community. Their project stakeholders come from various backgrounds, e.g., local government, small local enterprises, or farmers; therefore, the project theme is based on their stakeholder needs (the examples available in Table 2)

Table 2

The Stakeholder and Project Title Examples

Stakeholder	Project Title
Local government	Blind Audio Guide for Taman Pintar
Hospital	Portable Isolation Cover for Covid-19 Patient
Cocoa Farmer	Cocoa Bean Drying Machine
Small Local Enterprises	Monitoring and Control System in Atsiri Extracting
	Development of Belt Sander Machine for SME Rosse Bamboo in Seyegan Sleman
	Development of The Clamping Tool for Attachment of Laminated Bamboo in SME Rosse Bamboo Seyegan Sleman
	Printing equipment for products made from bamboo stems with gas-fired heaters
Stock Farmer	Cattle or Sheep Physical Parameter Diagnostic Tool
Health Research Center	Low-cost stethoscope for pregnancy
	Low-cost vein locator/ Vein Red

Procedure and Instruments

This study implemented two stages of data intake during June – July 2023. First, we collected data using a 30-minute self-report and open-ended questionnaire distributed by e-form. Second, we selected three participants for a 60-minute interview session. In the interview session, we expanded upon the information obtained from questionnaires. Table 3 shows the general guidelines for these two sessions.

Table 3
Open ended survey and interview general guideline

Aspect	Question Examples
General Process	Please explain your final project process
Community engagement process	What makes you decided to involve in this community based final project? How to ensure the community need?
Feeling and experience	What did you feel regarding your project implementation? What is the challenge during project implementation?
Values and perspective	What is the insight that you get after the project completion?

Data Analysis

We applied thematic analysis to analyze the data (Braun et al., 2019; Braun & Clarke, 2006, 2021) because of its flexibility in analyzing various kinds of data (Lester et al., 2020). Later, the analysis recognized as reflexive thematic analysis (Braun et al., 2019) explained that there are six phases : (1) familiarizing with the dataset, (2) coding, (3) generating initial themes, (4) developing and reviewing themes, (5) refining, defining and naming themes, and (6) writing up (Braun & Clarke, 2021).

Considering the limitation of thematic analysis, we follow the procedures to ensure trustworthiness in every phase (Nowell et al., 2017). However, we only implemented some of the processes recommended by Nowell et al. (2017) , so this is one of the limitations of this research. The primary processes implemented to increase credibility are two triangulation strategies out of four strategies (Patton, 2014), namely from the data source and multiple analysts. First, triangulation of qualitative data sources is implemented through data collection using surveys and interviews. Apart from that, we also involved participants from two engineering study programs that had implemented community-based projects. This number may need to be more representative; however, study programs implementing this approach are still limited. Second, triangulation with multiple analysts involves the research team (three people) in the data collection and processing process. This method is used to minimize bias and increase the consistency of the data obtained(Patton, 2014).

Result

As expressed by participants, we elaborated on the student's experiences with community-based innovation projects. We divided the result into five themes: (a) the idea exploration, (b) community need assessment, (c) project implementation, (d) participants' response regarding the project, and (e) value, perspectives, and competencies after the project was accomplished. The first three themes reflect the process of the student project, and the last two themes reflect the students' experience after the project. The process of the community-based project is described in Figure 1. The evidence provided in the quotes with the code of subject, the letter "S" reflects the survey participant, "I" reflects the interview participant, and the number after the letter reflects a unique code for each participant.

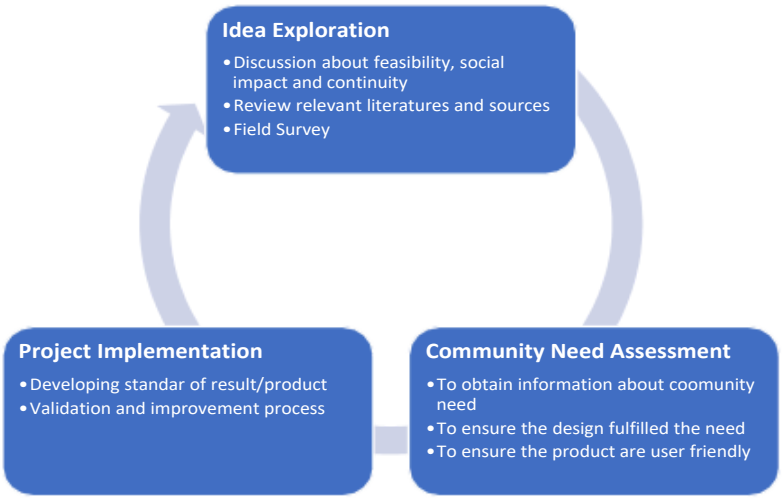

Figure 1. The process of community-based student project

Theme 1: Idea Exploration

In the first theme, we delved into the process of idea exploration that precedes students' decision-making regarding the project. Over 90% of students found their project idea from external sources, including friends or lecturers. Nonetheless, they proceeded to undertake several steps to further develop the initial idea.

The first step was discussing the projects' feasibility, social impact, and continuity. The students encountered different project situations. Some might get mature projects, complete packages of the idea, and the stakeholder; however, they still need to refine the execution of the idea into an actual product. In contrast, some of them got a rough idea, necessitating testing and further elaboration from the students. Furthermore, during the preparation phase, their discussion mainly revolved around the feasibility of the project. The discussion also includes evaluating factors such as the availability of the materials and technology, the availability and willingness of the future user, and market opportunity.

> *We used available materials and look at current technological developments to make the conversion. (S15)*
> *The first step is looking for information about the product or accessories that will be made to sell. (S16)*
> *After our lecture offered the idea, we looked for users willing to try and use the tools; we were grateful to meet cacao farmers willing to use our tools. (S9)*

In addition to assessing the feasibility, the students discussed the social impact and continuity of the project. They expect their idea to not only successfully implemented but also to hold enduring value once the project is completed and in the long term.

> *At the first, we discuss with the team about social impact, continuity, and asses real problem in community. (S2)*

The second step was reviewing relevant literature and other information source. Following the approval of the idea from the team and the lecturer, the students initiated their exploration of relevant literature and other information sources, such as scholarly journals, previous related research, web pages, and video.

> *I found the idea after reading literature and news and watching videos; after that, I bring it to discussion with my lecture. (S11)*
> *I gathered ideas from scholarly journals, academic literature, and my lecture suggestion. (S19)*

The last step in idea exploration was conducting a field survey. Most of them conducted field surveys as initial step to gather preliminary, assessing community needs or current available products/innovations. Additionally, some students performed interviews and made on-site visit.

> *This project required us to do a field survey to assess Small, and Medium Enterprise (SME) needs. (S37)*
> *At first, we could not figure out the sediment in shrimp farming. We decided to meet the stakeholder and visit the farming. (I3)*

Theme 2: Community need assessment

In the second theme, we expanded upon the finding that a community needs assessment represents a distinctive phase in a student's community-based project, compared to the conventional approach. During this phase, student conducted field assessments and engaged in discussion with stakeholders.

The assessment was a continuous process during the project and was conducted for several purposes. Firstly, it aimed to obtain information about community needs. To achieve this purpose, most students interacted with stakeholders, delving deeper into and refining the identified needs. This process was essential to decide the product and its features that they intended to create.

> *Based on the discussions with the farmers, we identified a problem with the drying process of the cocoa beans, which took a long time. (S9)*
> *The theme of this research came from the problems perceived by stakeholders. From the assessment, we knew that stakeholders need to monitor and validate the occurrence of violations in order to enforce regulations regarding the maximum speed limit. (S31)*

Secondly, the assessment aims to ensure that product design fulfilled the need. The students were required to translate the community need into technical specifications. This step was undertaken to confirm alignment with the stakeholder's requirements, ensuring the design or prototype effectively met the stakeholders' need. Some students recommend several options to the stakeholder, outlining the benefit and the consequences of each alternative. However, the final decision rested with the stakeholder. In this process, the student might need to adjust the design or prototype.

We did a detailed presentation of the tool design and confirmed whether it meets their requirements. They gave some suggestions to make the design better. (I1)

We offered three solutions for stakeholders and considered every option. Finally, they chose the first solution that we recommend as the best solution. (I2)

Thirdly, assessment is aimed at ensuring the end-product is user-friendly. The product should fulfill user specification while also being user-friendly. To achieve these, the students performed trials to ensure the proper functioning the product/prototype. Some of them provided user training on product operation. During this phase, they might undertake some revisions to improve the product.

I ensured my tool could be used because it made it easier for the user to measure and input the data. (S36)

We improved the display of the website to make the user experience better. (I3)

Theme 3: Project Implementation

The implementation phase commenced with designing a product based on stakeholder-defined specifications. Students built several standards for their expected product, as explained in sub-theme 3.1. Following this step, students validated the result to their stakeholder and made improvements through the validation process, as explained in sub-theme 3.2. At last, their product was generally categorized into a prototype and a finished product, detailed in sub-theme 3.3.

Sub-theme 3.1: Developing a standard of result for community-based projects.

The first standard is that the product or result should improve the work processes. Based on the assessment, the students recognized the potential to enhance the efficiency or the effectiveness by modifying the machines or refining the process.

It made stakeholder easier to carry out the process of monitoring essential oils using SCFE machines. In addition, to maximize the monitoring process in order to get good data to evaluate the essential oil extraction process. This project can also make the quality of essential oils better and increase the price because the process is monitored as well as possible so that they get better results than before. (S1)

The theme we are working on is to develop one of the existing tools in SME Rosse Bambu so they can work more efficiently. (S9)

The second standard is that the product or result creates something new. Some students design the expected product by addressing the stakeholder needs that are not fulfilled by current facilities/tools.

The park does not have a facility for blind people to enjoy the park. The park expects blind people to have better accessibility during their tour. (S2)
Currently, custom bicycle makers only make but do not test the bicycle frames that have been made. That is why we made the tester. (S7)

The third is that the product or result creates improved tools/mechanism. Some stakeholders faced difficulties because of tools/mechanism limitations; therefore, the student seized these opportunities to make the improved version that addressed these limitations.

Broiler-X and Faculty of Animal Science UGM need a tool to calculate cattle weight accurately. They use manual tools but are willing to have a more advanced scale using technology. (S4)
We researched mosquito-repellent devices. The tools currently available cannot cover the entire room and are static. That is why we present a mosquito-repellent device that can move dynamically. (S36)

The fourth is that the product or result serving as a solution for facility and resource limitations. Some products emerge from limited resources due to specific circumstances, such as the COVID-19 pandemic or inaccessible area.

My final project helps the hospital to solve isolation room limitedness for COVID-19 patients. (S3)
Many health workers face difficulties during a baby's catheter insertion because the baby's veins are so small than adults; therefore, this product will help them to find the veins. (S22)
Diagnostic tools for pregnancy in rural areas are still limited. The product will help health workers to diagnose the fetus's health during pregnancy. (S32)

The fifth is that the product or result should be more environmentally friendly than its previous version. Given the current trend toward eco-friendly industries, some students make the product

using natural materials. This not only aligns with environmental concerns but also presents a business opportunity for the community in certain areas because of abundant supply of such materials.

> *Excessive use of plastic materials will damage the environment. Therefore, we make printing equipment made from banana stems, an organic material with limited optimization. (S11)*
>
> *Our research theme aligns with the current development of bicycles or industries that use natural materials (wooden and bamboo bicycles). (S6)*

Sub-theme 3.2: Validation and improvement process

After the student accomplished the product, they conducted trials to test its functionality. This critical step usually involves the user validating the result; some changes might be implied to improve the result/product.

> *Our result is a website to monitor the sediment; therefore, after it is finished, we carry out the validation stage in shrimp farming for about 2 – 3 weeks to check whether it can provide the expected output. From data collection, we can calculate accuracy, sensitivity, and user experience. In this process, stakeholders suggested improving the product, and at that time, the suggestion was mostly on display, like the font. Based on their suggestion, we made some improvements. (I3)*
>
> *We could finish the result in a month, but after trials, we found the result was under specification. We told them we faced Wi-Fi connection difficulties in the cowhouse at that time. Furthermore, we did other trials over three months, and at last, we achieved a target of 1m/s in the improved version. (I2)*

Sub-theme 3.3: Result of the project

Generally, the result is divided into two categories. The first is a model/prototype that the stakeholder has tested but has yet to be used immediately. Whereas, the second category comprises products that have been approved/validated by the stakeholder for immediate usage. More than half of respondents claimed that their products were ready to use by stakeholders.

In terms of first category, there are at least two situations that make the result end up as a prototype. The first scenario occurs when the result is designed as a mass product and needs further review or testing. The second arises because of the project time restriction, resulting in some outcomes end up as prototypes that necessitate further improvement to be used by stakeholders.

The resulting tool is a prototype that is not yet ready for mass production and needs to be reviewed for accuracy. (S32)

The tools we produce need further development for more ergonomics. (I1)

On the other hand, the second category includes the product directly used by the user/stakeholders. This product type has met the user specification and can be directly applied to fulfill user needs.

This tool has been used for safety training by study programs/departments. (S10)

The Belt Sander Machine has been handed over and used by SME Rosse Bambu. (S37)

Theme 4: Participants' Response Regarding the Project

All the participants expressed positive feelings regarding the project. Some of them felt enthusiastic because they could realize the idea.

I am happy because the tool can be further developed and mass-produced. (S10)

I am happy because I realized the proposed system that I made based on stakeholder problems. (S31)

The positive feeling arose from the connection between the student and the community. Several students felt self-meaningful because the project had a meaningful impact on the stakeholders.

I am happy and grateful because this final project can be useful for increasing the productivity of UKM Rosse Bambu. (S36)

I feel delighted and proud because I can help those who need this facility. (S13)

However, several students stated feeling a sense of self-fulfilled because they could apply knowledge to benefit the community.

I am pleased when I have the opportunity to apply my knowledge directly to the community and mingle directly with the community. (S27)

Theme 5: Values, Perspectives, and Competencies After the Project Accomplishment

All students stated that the project changed their values and perspectives, especially those related to the community. First, the shift in perspectives involved bridging the gap between theoretical and practical aspects of the community. Students felt that this project transforms "abstract" theory into actual practice during the project implementation.

> *I used to ignore the basic theory, but I realized that basic theories are essential daily. (I2)*
> *This project has influenced my perspective because I can implement the knowledge gained during lectures into my final project. Therefore, this knowledge is useful for the community, especially stakeholders who work together on this project. (S7)*
> *This project certainly greatly influenced my perspective. The implementation of science is flexible, so we have to balance theory and practice to make the results of this research effective. (S9)*

Interestingly, their collaboration with the community during the project led to the development of a different perspective: that innovation should be align with the community's needs.

> *Yes, the results of the final project have opened my perspective as a student that we have to plan every project to fit the reality in society. (S23)*
> *This project affects how we solved a problem in the field and tried to improve work systems to increase work productivity. (S8)*

Continuing from the previous perspectives, the engagement with the community also changed their values regarding their way of thinking and social role.

> *During my final assignment, my views were more open regarding how we, as a society and Muslims, can benefit others by making innovations or discovering new tools that benefit many people. Many people need technological advances in order to be able to solve problems that they have not been able to solve before. (S21)*
> *This project can create a sense of sensitivity, concern for fellow human beings, and a sense of helping each other to solve problems. (S19)*

Besides community values and perspective, this project boosts students' individual and social competence. The students perceive improvements in problem-solving, communication skills, and teamwork.

> *After working on this project, I have a coherent and logical way of dealing with a situation. In a condition, it is important to realize what problems occur that create the needs. The needs should be addressed with a solution that may have limitations. That limitation is the primary source so that the designed solution is right on target. Apart from that, it is also important to know personal abilities to realize the solutions designed properly. (S31)*

> *Working with the stakeholders enhanced my communication skill in delivering my argument to my superior and tried to meet both parties' requirements (stakeholders and study program). (I3)*
> *The challenge comes from our team, especially in managing and defining roles and tasks. From the stakeholder, we learn how to communicate politely and effectively, alhamdulillah we have no problem. (I2)*

Discussion

Engineering is an activity essential to meeting people's needs, fostering economic development, and providing service to the community (International Engineering Alliance, 2013). Consequently, engineering education should design the process and result closer to the community's needs. For this purpose, universities should provide students with soft and hard competencies, a task that traditional learning—focused on passive student reception—cannot fully accomplish (Guo et al., 2020). Therefore, engineering education should stimulate students to be more active and engage with their learning process while actively participating as community members.

Community-based projects that combine community-based research and project-based learning strategy primarily implemented in the health and social science field (Abraham & Torner, 2021; Anderson, 2002; Case, 2014; Mello-Goldner, 2019; Ochocka & Janzen, 2014; Strand, 2000) as opposed to the engineering field (Chen et al., 2020; Goggins & Hajdukiewicz, 2022; Mebert et al., 2020). This study presents three major stages in engineering's community-based student project: idea

exploration, community needs assessment, and project implementation. The stages slightly differ from the stages of community-based research in the social field (Ochocka & Janzen, 2014), although both have a unique feature in community involvement at every stage. Projects with community characteristics require community engagement throughout design, execution, and utilization phase, as they are the main focus of the research project (Ochocka & Janzen, 2014).

At the early stage—the idea exploration, the students followed the typical process just like the final project in general, namely conceptualization and early task in research. However, they have more complex considerations than usual, and they should think beyond typical project feasibility. Since the first step, they incorporated social aspects: usefulness and project sustainability. This distinction emerged because the community-based project's primary purpose is to benefit the community; hence, the students focused on outcomes that aligned with the community's interests, feelings, and goals (Strand, 2000). Furthermore, because they worked with the community, the essential goal became achieving mutual purposes rather than competing with other students for good grades (Strand, 2000). The idea exploration process intends to lay the foundations where the researchers (students) and the community (stakeholders) clarify their purposes and own roles (Ochocka & Janzen, 2014). The primary outcome of this process is that students understand the situation's context and purposes to articulate the idea into coherent plans.

After idea approval, students begin to assess the community's needs. This phase involves a comprehensive elaboration of the need specifications by gathering stakeholder data. Previous research defined this stage as a planning phase and information gathering/analysis (Ochocka & Janzen, 2014). The process is characterized by detailing the project, method, data gathering, and analysis (Ochocka & Janzen, 2014). This essential stage aims to carry out a project that meets some community needs as defined by the community, not by the researcher or other experts (Strand, 2000). It is achieved by recognizing the legitimacy of the knowledge and world views of the community in every research stage (Strand, 2000). The community is regarded as "the expert" with knowledge and experience about their problem. Typically, students may communicate frequently with community partners to understand their goals and partnership expectations (Abraham & Torner, 2021). When the student team and stakeholders are seen as a team during this project, setting expectations in this phase is essential to prevent miscommunication from becoming an issue and

ensure everyone understands their respective roles (Mello-Goldner, 2019). The result showed that ensuring the community's needs is a continuous process until the project's completion.

In the final phase—the project implementation, students apply the planning approved and confirmed in previous phases. Interestingly, students gained an understanding of the standard of the result that all of them are community benefit-oriented and innovation-oriented. Unintentionally, students implemented the standard that aligned with the characteristics of social innovation projects, namely social, genuine, original, and transformative (Carvache-Franco et al., 2018). This characteristic highlights the social benefit, community involvement, and positive change after the project. In addition, this innovative standard is shaped because the project implements project-based learning strategies that enable students to have a very well-defined framework (Charosky et al., 2022).

The further process in the project implementation phase is the validation process to ensure the results fulfill community expectations. This process reflects that community-based research sees the community as the owner of the pool of knowledge (Ochocka & Janzen, 2014) and the decision maker (Anderson, 2002) in the research project, not only as the end user of the outcomes. In this phase, the student mobilizes the knowledge to ensure the product result can be used or operated by stakeholders. Creative delivery ways might be needed to fully engage stakeholders in sharing results and stimulate further ideas (Ochocka & Janzen, 2014).

The project's result is divided into two categories—prototypes and final products. The first type—prototypes—results in a model or pilot product necessitating further testing or development by the user/stakeholders. Usually, people see prototypes as less valuable and underutilized than the final product (Carfagni et al., 2020; Deininger et al., 2017). However, prototyping is one of the most crucial phases in product design (Lauff et al., 2018), and the result is often used for communicating, exploring, refining, and gathering user feedback (Carfagni et al., 2020). In this project, prototypes are handed over for testing and subsequent user-driven development. The second type comprises the final products, which user can directly utilize. This result proves that by using community student projects, engineering can contribute effectively and positively without leaving a negative legacy for the community and environment (United Nations Educational Scientific and Cultural Organization, 2010).

The results in themes four and five describe the positive impact of the community-based project on students' affective, cognitive, and skills. All the students have positive feelings regarding the project for various reasons: personal-oriented reasons and community-oriented reasons. This result aligns with the previous research indicating that while community-based research might take more effort and resources for students, the resulting rewards are noteworthy as their design comes to fruition and is beneficial for the community (Anderson, 2002). Furthermore, they acquire a new appreciation of research connection to people's lives (Strand, 2000) and realize that their work can respond directly to community needs (Goggins & Hajdukiewicz, 2022).

Besides the feeling, positive changes are found in students' cognitive skills and values. The participants reported that their logical thinking was increasingly honed during the project. Participating in the actual problem required them to think systematically and critically to provide alternative solutions (Guo et al., 2020) by applying basic theory to practice. Beyond cognitive growth, due to their involvement in the community, this project boosts various social competencies among students. The community-based project facilitates the students to build a positive relationship with stakeholders (Anderson, 2002) that requires them to communicate frequently and professionally (Abraham & Torner, 2021). Consequently, the situation stimulates the students to decide communication strategy and practice it appropriately and effectively: listening to the community needs and simultaneously translating technical language into an understandable term.

Finally, as ultimate changes, community-based projects exert profound influence on students' values, especially social values dan citizenship. These projects equip students with the ability to function as active members of the community, guiding them on how to participate responsibly and engage in socially conscious actions (Mello-Goldner, 2019). Furthermore, the project elicits their sense of empowerment because they are involved in community problem-solving (Mebert et al., 2020). Previous studies showed an aligned result; students percept the project to increase their citizenship, social responsibility, and application of knowledge (Chittum & Finley, 2022; Mello-Goldner, 2019). Interestingly, in Indonesia—the most religious country in the world (Iswara, 2020), participants relate their research experiences with their role as believers. Muslim participants in this study draw parallels between their project engagement with the Islamic values about giving benefit to the community. From these responses, we have insight that community-based project also evokes their cultural

awareness. This experience will help the students have a deeper understanding of their community, which will assist them when entering future careers and roles (Abraham & Torner, 2021; Mello-Goldner, 2019).

This study has shown the positive dynamics and changes of community-based student projects in engineering. Nonetheless, we acknowledge that the methodology employed in this study follows a qualitative approach, which might have limitations in terms of its generalizability (Mwita, 2022). This study uses a limited range of participants on certain characteristics and specific fields of knowledge in engineering. Therefore, it is essential to be attentive before making an extensive conclusion, especially in different fields. Moreover, several different research conditions, such as the readiness of research themes and tools, were not explicitly differentiated in this study. Consequently, a more comprehensive elaboration for specific situations becomes essential, calling for further in-depth exploration.

Conclusion

This study has identified the stages of community-based projects in the engineering field, which were slightly different from the stages in the field of socio-humanities. The experience of community-based projects positively influences students at cognitive, affective, and skill levels. Beyond serving as the culmination of learning in higher education learning, the project also provides additional value by fostering the social and community-oriented values, thereby benefiting students in carrying out their roles in the future.

Considering some limitations in practice from student experiences, we believe that there are great opportunities to improve the community-based student project. First, universities can improve the design by constructing collaborative projects with several study programs involved. Community problems need more than technical solutions; thus, collaboration with other fields is needed (Chen et al., 2020) to solve the problem comprehensively and to positively impact the community. Universities also can modify a similar design into a smaller assignment scale due to the potential for increasing academic achievement through this project (Guo et al., 2020). Second, this community-based project learning model requires further quantitative studies to investigate its impact on more precise and measurable aspects. Third, the results of this study indicate that there are several things

that need to be prepared in the community-based project course in a more structured manner, including several issues related to ethics, establishing communication skills, and the community needs assessment process. Fourth, it is essential to hear community evaluation as this project's central focus. In addition, the project result monitoring will be valuable for future community-based project design.

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