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Integrated Project in Separation Process Class as Innovative Tool to Improve Students' Online Learning Experience

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Abstract

Implementation of integrated project in chemical engineering courses has shown positive impact on students' understanding, teamwork, critical thinking, and communication. In this case, an integrated project covering three different courses in chemical engineering, namely Reaction engineering, Process modelling and simulation, and Separation process was formulated on palm-oil based biodiesel production and introduced to students. The response from questionnaire was recorded and analyzed by using Excel software. More than 90% of students agree that the project helps them to understand the course and prepare for test or exam. While more than 70% of students want to see this type of project for other courses. Majority of students think that collaboration and teamwork help them to finish the project and doing integrated project saves their time to do assessment. Beside improving their soft skill like critical thinking, students can also sharpen their technical skills in solving the problems, especially on process flow drawing, operation of simulation tool, calculation technique, and search for suitable information and data. Through this integrated project, students could explore the connection among courses in Chemical Engineering program and implement the taught concepts in solving engineering problem, which can be challenging things to achieve during online learning.

Keywords: Integrated project; Separation process; Biodiesel; Soft-skills; Technical skills

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INTRODUCTION

Online learning during the pandemic and post-pandemic era has been quite challenging for education institutions, especially on improving their teaching pedagogy while maintaining the quality of learning experience (Scholes, 2021). Fortunately, this challenge provides more opportunities to explore and transform teaching and learning experience through various methods such as gamification (Tsay et al., 2018), massive open online courses (Wong et al., 2019), project based learning (Sultanova et al., 2021), and many more. The usage of problem-based learning (PBL) technique has been accelerated during the pandemic. Study by Haslam et al, shows that during pandemic, students miss face-to-face engagement and on-campus activities (Haslam et al., 2021). Hence, they found it difficult to stay motivated and focus on learning (Haslam et al., 2021). The collaboration nature in PBL could facilitate

students to interact and discuss with their peers and instructors, which can counterbalance the lack of social connections (Haslam et al., 2021).

In chemical engineering, process design is integral part of curriculum that require students to apply their acquired knowledge, and in doing so, integrating concepts and working in a team with unparallel skills have become necessary (Lewin, 2021). Therefore, instilling some of process design concepts in earlier semester could train students' common sense and help them to gain some experience. Integrated project is usually done by combining assessments from some taught courses in the same semester (Ruslan et al., 2021; Sambudi & Ramli, 2021). This type of project is intended to relate between the taught courses in same semester, introduce complex engineering problems to students, and avoid high utilization of students learning time for projects, in case when several projects are introduced at the same time. Previous reports on implementation of integrated projects show the development of students' soft skills, especially on problem solving, time management, leadership, and communication are improved through this type of project (Nik Him et al., 2015; Ruslan et al., 2021; Sambudi & Ramli, 2021). While in this study, integrated project is implemented to familiarize students with ASPEN HYSYS, improve students' understanding in selection of equations and scientific concept, as well as communication and teamwork.

Separation process course introduces students to various types of instruments to separate and purify chemical products. Various capstones projects will require students to apply the concepts of distillation, crystallization, absorption, and other separation methods. Additionally, critical things such as reaction routes, basic simulation and selection of separation method are fundamental skills for working on process design (Ocampo-López et al., 2022). Therefore, in this project, reaction engineering, process modelling and simulation, and separation process are combined under one big assessment with complex engineering problem. Many students face difficulties in connecting the concepts taught in these three different courses. Hence, through this integrated project, the students will be able to connect the concepts through solving an engineering problem and implement the necessary equation and simulation tool. This way, they will be able to see the general concept of chemical engineering. The use of simulation tool such as ASPEN HYSYS and process drawing tool allows students to improve their technical skills and understanding of process flow, which is beneficial in preparing them for main capstone project in their final year.

The outcome-based education (OBE) has proposed innovations to improve the delivery of knowledge, teaching styles, and interaction between lecturer and students which are adopted widely by education institutions around the world. The rapid delivery of information and one-way teaching are closely associated with traditional education system which could lead to students' low quality of learning (Bagban, 2017). OBE has also been defined as result-oriented education which emphasize on the design of assessment techniques to improve the quality of students' learning (Bagban, 2017; Jadhav et al., 2020).

The echo of generating university graduates with sets of skills that could prepare them to face the needs in industry has penetrated the curriculum planning of engineering schools. To achieve this goal, improvement of quality of students' engagement during teaching and learning process has been explored through various pedagogies. Problem based learning (PBL) is one of effective pedagogy that has been

widely used for improving the learning experience of engineering students (Kuppuswamy & Mhakure, 2020). By using case study with complex engineering problems, students could apply the taught knowledge, communicate effectively in a team, think critically through brainstorming, learn independently, and sharpen their problem-solving skill (González-Pérez & Ramírez-Montoya, 2022; Kuppuswamy & Mhakure, 2020; Lutsenko, 2018; Nik Him et al., 2015). PBL is also known to promote better retention of knowledge by researching on case study and high-level reasoning skill through comprehension of complex-real problem (Farmer, 2018).

Design of assessment should be inclusive and could address the critical and higher thinking of students, as well as problem solving (Bagban, 2017). The assessment needs to also facilitate the connection between concepts and theories taught in class with real life situations (Bagban, 2017). While during the implementation of project, students are encouraged to collaborate and discuss with their team members and lecturers to form creative solutions (Bagban, 2017; McCrum, 2017). The learning process in working on assessment can include brainstorming ideas and relate them with known concepts and knowledge, searching for method and equations or underlying patterns, examine logics and arguments critically, and conclude the work (McCrum, 2017).

According to the concept of PBL, students should be the center of learning, hence self-learning skill is required. However, this skill can be quite difficult to be attained due to lack of motivation and conflicts during teamwork (Chen et al., 2021). Therefore, arrangement of regular consultation between students and lecturers as well as proper training should be considered to achieve smooth implementation of assessment and further improve students' use of knowledge (Chen et al., 2021).

OBE system is also closely related to active learning (AL) to promote students' self-learning, and PBL is a form of complex AL technique. PBL could facilitate retention and understanding of knowledge through engagement in problem analysis, recall of previous knowledge, training of technical skills, planning and discussion (Hernández-de-Menéndez et al., 2019). This technique facilitates students to work hard through discovery-learning, which develops their self-efficacy.

METHOD

The integrated project was arranged in September 2021 semester during online learning period. This project involves Chemical Engineering students from Universiti Teknologi PETRONAS (UTP), Malaysia and exchange students from Department of Chemical Engineering, Institut Teknologi Sepuluh November (ITS), Indonesia, which comprise of 149 students (110 students from UTP and 39 students from ITS) in their second year of study (Semester 5 for UTP students and semester 4 for ITS students). The students were divided into 31 small groups, with each group consists of 5 to 6 students. The project covers 3 courses: CEB2043 – Reaction Engineering I, CEB2053 – Process Modelling & Simulation, and CDB/CEB2063 – Separation Process II. The project was formulated based on the case of palm oil-based high-quality biodiesel production. For Separation Process course, students were asked to complete following tasks.

1. Provide the drawing of overall process flow diagram (PFD) of biodiesel production by using suitable software.
2. Design a suitable separation process system to improve the quality of biodiesel. The team needs to draw an overall block diagram for the separation process system.

The operating conditions (temperature, pressure) must be included in separation unit. Molar flow rate for each component in all the streams (entering or exiting separation unit) must be included/shown in the block diagrams.

3. Description on how the chosen separation system works for quality improvement of biodiesel.
4. Provide the information on the separation unit material, type, configuration, and the schematic diagram showing separation unit using Ms Visio or AutoCad or other appropriate software.
5. Provide the mass and heat balance or flux/rate calculations and/or other appropriate calculations related with the separation unit.

At the end of project, the students need to submit final report (not more than 10 pages) and a 10-minute length presentation video. The semester was arranged for 12 weeks, with around 8 weeks given for completion of project. Formulation and arrangement of project is shown in Fig. 1. The students were allowed to do the self-arrangement of their groups based on gender mix and ethnicity. Additionally, students were given training on ASPEN HYSYS for each of course on week 4 to week 9.

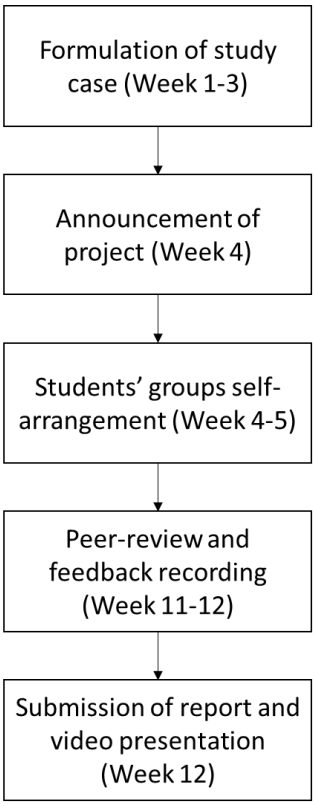

Figure 1. Flow of project planning.

The questionnaire was distributed to student at week 11-12, and the data was analyzed by using Excel and Origin software. The trend of students marks before and after taking integrated project was analyzed by using Excel software.

RESULTS AND DISCUSSION

In this project, students were required to produce simple PFD drawing (Fig. 2) by using available software. Engineering drawing is one of important domains for chemical engineering students, as it requires technical competency and an

introduction to complexity of real project (Ricaurte et al., 2022; Ricaurte & Viloria, 2020). During the completion of separation process tasks, students were encouraged to select the appropriate instruments to purify the product from chemical reaction and apply the necessary calculations to complete them. When the integrated project was implemented, the courses were conducted online; hence students had limited interactions among them. PBL approach has been widely introduced in many chemical engineering courses to correlate the concepts taught among courses at same semester for an engineering case study. Such approach can induce deep learning and improve the soft skills of students (Mellon et al., 2017). This can be due to complex engineering problem that can be formulated from the integration of three courses, which the solutions for each course-assigned problems can be synergistic and related (Al-Obaidi et al., 2013). The students' experience so far has been positive toward implementation of integrated project, which are shown in polling results in Fig. 3 – 7.

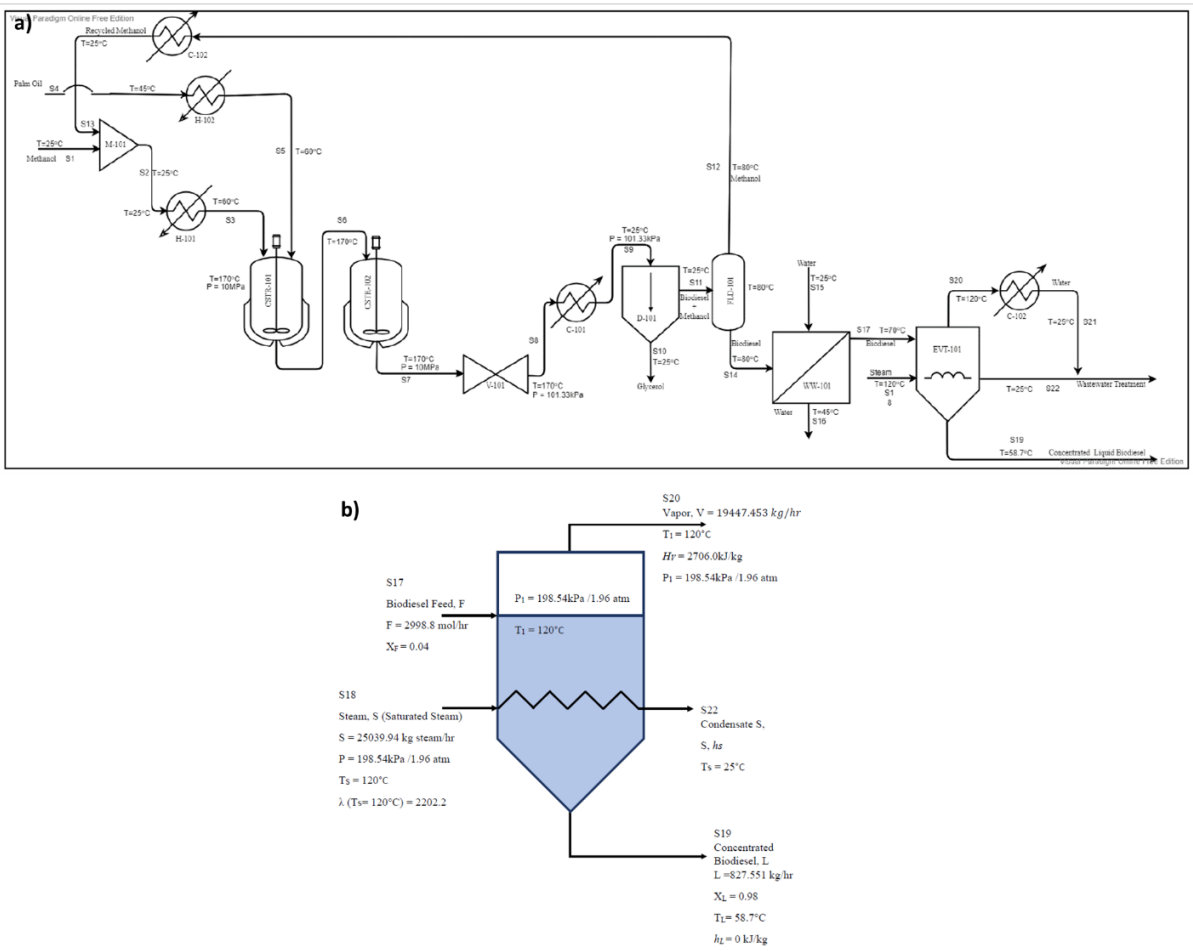

Figure 2. Sample of students' work. a) Process flow diagram (PFD) of biodiesel production from palm oil and b) evaporator as a separation unit.

Majority of students strongly agree that the integrated project help them in understanding the course and preparing for test or exam (Fig. 3 and 4). Project-based problem relies on self-study, and open-ended style problems (Mielikäinen, 2021). To limit the self-interpretation, boundary conditions and targets achieved related to problems were given; however, students were asked to provide suitable assumptions. This way, each group may come out with distinct solution and confusions can be avoided. Students were encouraged to explore the topic, implement the concepts and

equations learned in class to real-case, and formulate the solutions within the context. This will stimulate their understanding upon materials that they have studied, which they may revisit and restudy, as well as induce creative thinking in revealing the steps taken to produce solutions (Hasibuan, 2022; Trisdiono, 2019). In doing all these, strong commitment, collaboration, and teamwork are key-defining factors in producing excellent results.

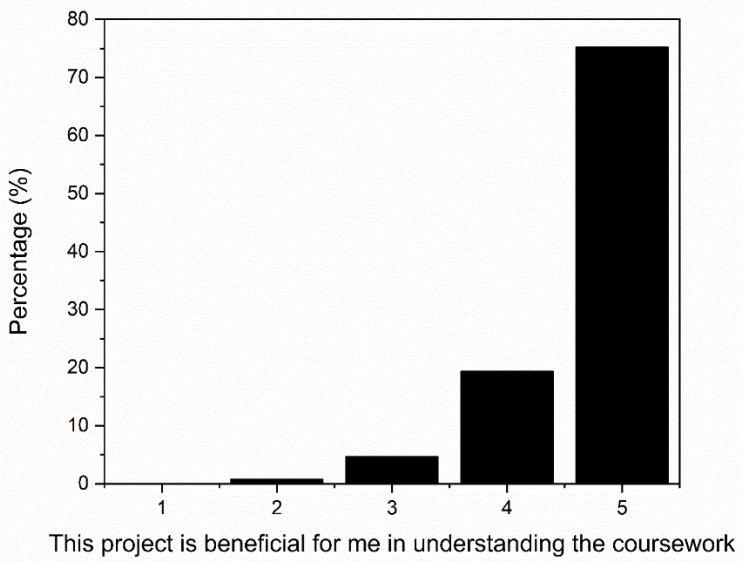

Figure 3. Polling on whether integrated project is beneficial in understanding the coursework. 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

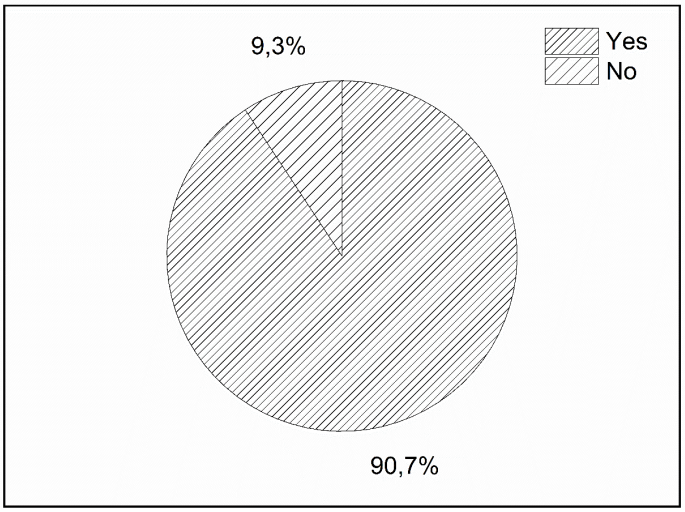

Figure 4. Polling on whether the project helps to prepare test/final exam.

The project achieves the intended soft skills to be acquired by students, which are collaboration and teamwork among them as shown by the agreement of majority of students (Fig. 5). This can be shaped from sharing of information, discussion, tasks distribution, and dealing with arguments which train them to develop emotional intelligence and to finally have effective collaboration (Krissadee et al., 2022).

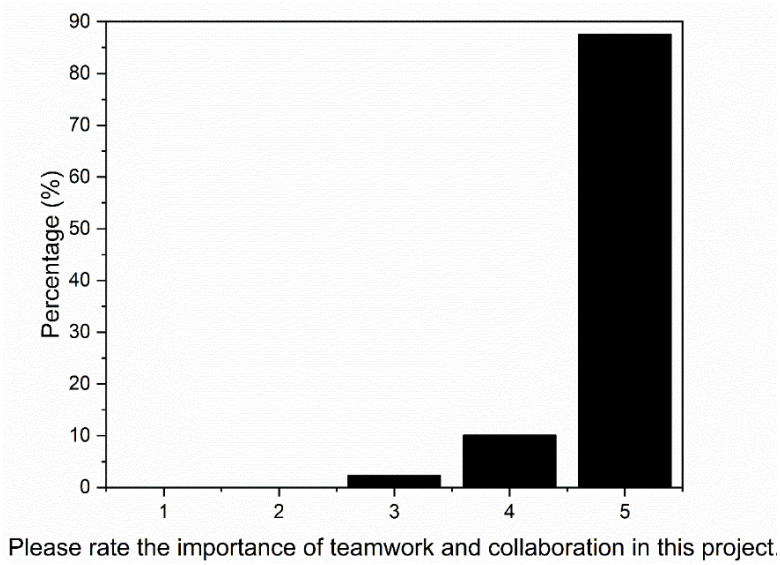

Figure 5. Polling on importance of teamwork and collaboration. 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

Around 73% of students would like to experience integrated project for other courses, and around 84.5% agree that this type of project saves their time for working on assessment (Fig. 6 and 7). Professional skills such as communication, organisational abilities, teamwork, and time management have been included in requirements for accrediting engineering (Picard et al., 2022). The steps to complete the tasks should be organized around the time given to students to complete the project. Hence, adjustments of plans will be likely done by the groups, as well as allocating enough time for each set of questions. Even if the process seems complex, most students still prefer to do integrated project rather than separated ones, which can be due to a merged engineering case is offered for three courses instead of having separate case study, although the tasks given are more comprehensive and details. Based on feedback from students, not only soft skills such as critical thinking that was enhanced, but also technical skill such as PFD drawing, calculation technique, simulation software operation, and data and information searching (Fig. 8).

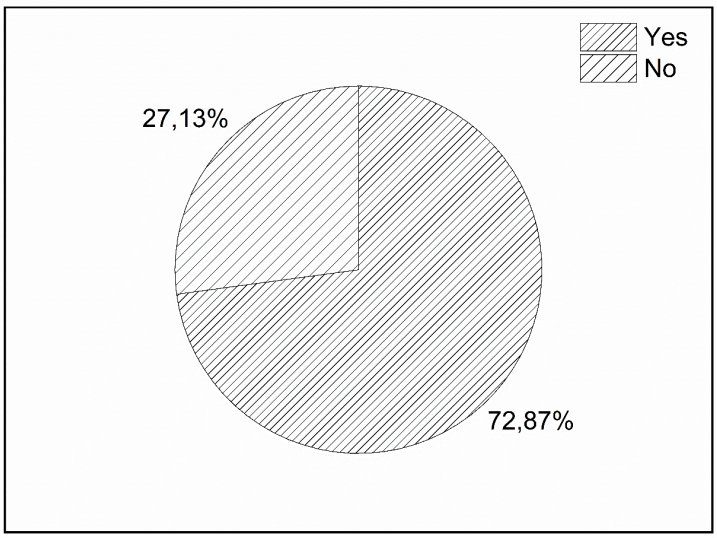

Figure 6. Polling on whether the students want to see this type of integrated project in other courses.

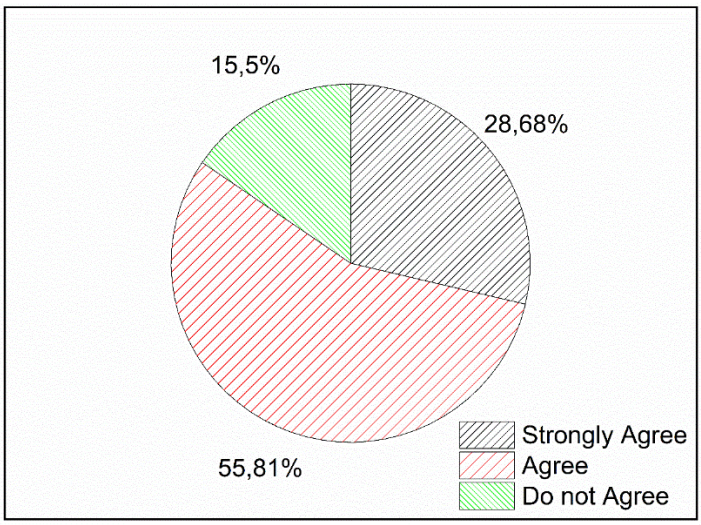

Figure 7. Polling on whether integrated project saves more time compared to separated projects.

The improvement of knowledge transfer has been highlighted as an attractive achievement of PBL (Trullàs et al., 2022). Since PBL starts with study case or problematic situation, students need to formulate hypothesis, relate to certain concepts, select the equations, brainstorm ideas, and sharing information (Trullàs et al., 2022). In separation process course, the concepts rely heavily on implementation of equations for each separation instrument. Hence, students can sharpen their skill on calculation technique. Additionally, due to nature of open-ended study case, students need to provide suitable assumptions, which can be based on published studies related to biodiesel production; hence the mentioning of data and information searching in gained skill (Fig. 8). As chemical engineering students, process design-thinking is one of core competencies that should be acquired by students (González-Pérez & Ramírez-Montoya, 2022). Other technical competency needed to face Industrial Revolution 4.0 relates to students' ability to operate a simulation tool for chemical process. Hence, students were asked to simulate the biodiesel production by using ASPEN HYSYS. They also need to draw simple PFD by using available software such as Visual Paradigm. By exposing them to these tools, we expect them to be familiar with the elements of process design, which will be comprehensively done in final year through capstone project. In general, this integrated project successfully combined three courses under one study case which relates to chemical process design. The feedback from students showed positive impressions and they could gain soft and technical skills. Such-type of project is expected to prepare them for more complex case study in the future that they might face in more advanced courses, as well as to prepare graduates with well-rounded qualities. The analysis of students mark distribution during the semester for Chemical Engineering Thermodynamics course shows that there is increasing in average marks after the introduction of integrated project. The students' average mark before integrated project is around 68 ± 16.1, while the average mark after the introduction of integrated project is around 78.2 ± 10.25.

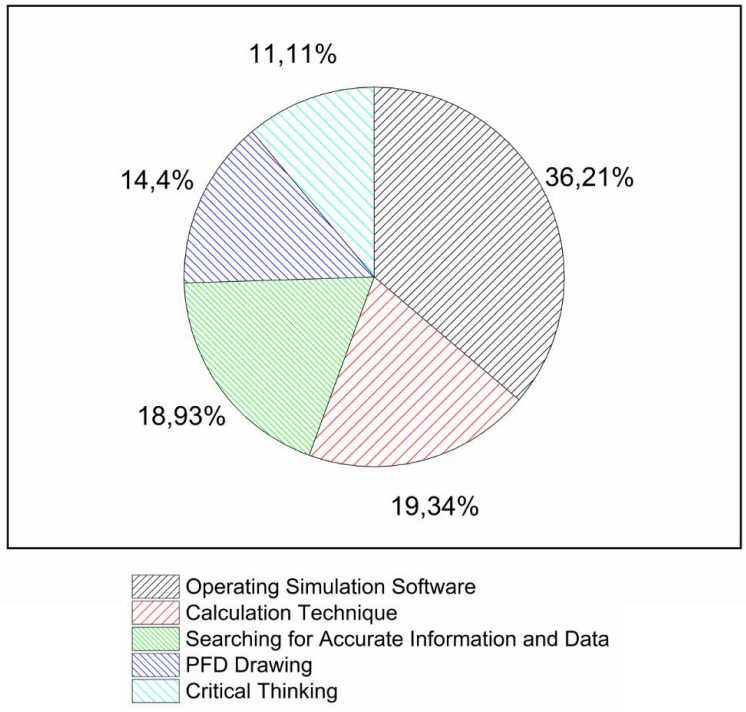

Figure 8. Polling on new skill learned from working on project.

CONCLUSION

The implementation of online learning during pandemic could be a challenge for students due to lack of social interaction and discussion among their peers. By introducing a case study and arrangement of group project, students can engage in meaningful discussion and brainstorm, hence the active learning activities among them are stimulated to keep them motivated. Through integrated project, students can correlate the concepts of core engineering courses that they take at same semester. Reaction engineering, Process modelling and simulation, and Separation process are courses that relate to process design. Hence, the experience of working on case study about biodiesel production will expose them early to some complex problems related to process design. At the end of project, students show their satisfaction towards the application of technical skills that they gained to solve the problems. Besides, they were conditioned to rely on their team to provide necessary solutions, and to do this they need to communicate and share information with team members. This type of project is beneficial to enhance students' interaction and knowledge on various taught concepts during the online learning period.

RECOMMENDATION

In this project, briefing on case study was done at the introduction of project to students, which is week 4. The monitoring of students' progress can be added into the implementation, probably on week 8 or 9, to make sure the discussion, calculations and simulation are properly done. At this week, observation on students' ability to operate simulation software can be done as well. If students do not perform well in simulating the process, additional session can be arranged for simulation lab to clear up their confusion.

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Declaration of interests

The researchers declare no conflict of interests.

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