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Achieving Future Competencies: Integrating Project-Based Learning and Simulation to Develop 21st Century Skills

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Abstract: This study aims to develop students' skills through the integration of project-based learning and simulation. This study used mixed methods by involving 30 students of the Mathematics Education Study Program at Universitas PGRI Sumatera Barat as research subjects. Data collection was conducted through observations of five meetings and semi-structured interviews with nine students of various academic ability level, including high, medium, and low. The research instrument for quantitative data was an observation sheet, while for qualitative data, a semi-structured interview sheet was used. The data obtained were analyzed using descriptive statistical analysis techniques for quantitative data and thematic analysis for qualitative data. The results of the study showed that the students' skills were not evenly distributed. Group collaboration in learning proved to be successful in increasing cooperation skills up to the high category, which indicates the effectiveness of learning in creating active interactions between students. However, other skills, such as creativity, communication, critical thinking, and innovation, are still in the medium category, which indicates that they still need further improvement and development. This study concludes that the integration of project-based learning and simulation has a positive effect on the abilities of students with uneven abilities. The integration of these learning approaches works synergistically by effectively linking theory and practice. Through project-based learning, students are encouraged to take an active role in designing, managing, and completing projects that directly contribute to their skill development. On the other hand, simulation functions as a complement that strengthens the effectiveness of project-based learning by presenting a real representation of the project by visualizing abstract concepts and allowing students to test the solutions they develop based on the project results.

Keywords: ability, competency, project-based learning, simulation, skills.

▪ INTRODUCTION

In the face of rapid technological development and increasingly complex global challenges, the education sector faces inevitable pressures (Singun, 2025; Mohamed Hashim et al., 2022; Oke & Fernandes, 2020). This challenge implies that the education sector must ensure that future generations have relevant skills and the ability to adapt to their environment. In this era, it is not enough for students to have basic knowledge; they must also be supplemented with skills such as problem-solving, creativity, critical thinking, cooperation, and other skills. Therefore, the need for an integrated approach is becoming increasingly urgent. Careful use of technology allows educators to select and use technologies that suit learning needs (Bizami et al., 2023; Antonietti et al., 2022), starting from online platforms to interactive learning applications. This opens up access to diverse educational resources, provides a more immersive learning experience, and facilitates collaboration and communication between lecturers and students. Meanwhile, the development of innovative, dynamic, and responsive learning methods requires

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educators to continuously update learning approaches that are interesting and relevant to the times (Haleem et al., 2022; Tetzlaff et al., 2021).

In the 21st century, students are faced with some challenges in developing the necessary skills. One of the key challenges is developing the range of skills needed to analyze information, identify problems, and find innovative solutions. Studies show that many students struggle to develop these skills, often just memorizing information without really understanding and applying it in real situations (Svensson et al., 2022). Another challenge is digital literacy and technology skills. In today's digital era, the ability to utilize technology effectively, as well as evaluate and use digital information critically and responsibly, is crucial (Haleem et al., 2022; Falloon, 2020; Hafizah et al., 2018). However, many students do not fully have these skills. In addition, in the world of work, the ability to communicate effectively and collaborate with people from diverse backgrounds is also essential (Ellitan, 2020). Finally, creativity and innovation are also key factors for success (West & Sacramento, 2023; Wannapiroon & Pimdee, 2022; Han et al., 2021; Lee et al., 2020). However, the education system often does not encourage the development of these skills, so many students lack skills in creative and innovative thinking.

To overcome this challenge, an integrated approach is needed that can create a supportive learning environment and facilitate the development of these skills. Theoretically, the integration of project-based learning and simulation is powerful, as they complement each other in creating an immersive and effective learning experience. Project-based learning provides opportunities for students to be actively involved in designing, managing, and completing projects that demand real problem-solving, thus encouraging the development of critical thinking, creativity, collaboration, and communication skills. On the other hand, simulation provides a learning environment where students test abstract concepts and solutions designed in project-based learning through hands-on experiences that replicate real-world situations. Thus, the integration of these approaches creates a strong synergy where project-based learning provides a relevant context for meaningful learning. Meanwhile, simulation strengthens students' understanding by exploring and validating their project outcomes. In addition, the integration helps students reach their optimal potential, with the simulation acting as a connecting tool that helps clarify and reinforce the learning outcomes of the project.

The study by Hsia et al. (2021) showed that learning approaches have great potential in fostering collaboration and problem-solving skills in students. The study highlighted the need for an approach to integrating learning methods. In addition, the use of technology is necessary for learning to develop skills such as creativity and critical thinking. Previous studies have shown that many educational institutions still tend to use traditional and less flexible learning approaches, which emphasize knowledge over skill development (Børte et al., 2023; Kerimbayev et al., 2023; Liu et al., 2020). Their studies highlight that conventional learning approaches still dominate at various levels of education, despite the current global demands for skilled students. Similar findings also show that the lack of integration of learning models that focus on skills development has led to a gap between the needs of the job market and the competencies that graduates possess (Prikshat et al., 2020; Pereira et al., 2019; Okolie et al., 2019; Ornellas et al., 2019).

One solution that can be applied is the integration of project-based learning and simulation to harmonize learning practices to facilitate knowledge transfer, and skills development that are relevant to the needs of the modern era. In learning, the integration of project-based learning and simulation is implemented through project activities. As part of project-based learning, students are asked to design a model using the principles of the topic studied. To support this project, software-based simulation, such as GeoGebra, is used. Students use this software to visualize their designs, modify them, and analyze their projects based on the principles and properties of the topic. Students can use the simulation to test and evaluate their projects. These simulations can help them understand abstract concepts in the context of real applications.

Previous studies have shown that project-based learning (PJBL) significantly improves student engagement and learning outcomes. Through PJBL, students are exposed to real situations or problems that they must solve independently or in groups, thus encouraging the development of critical thinking, problem-solving, communication, collaboration, and creativity skills. By working on projects collaboratively, students can practice communicating and working together. A supportive learning environment can encourage creativity and innovation and provide space for students to explore and experiment (Henriksen et al., 2020; Hero & Lindfors, 2019). In addition, the integration of supporting technology in the learning process is also an effective solution to improve students' digital literacy and skills (Yeşilyurt & Vezne, 2023; Marín & Castaneda, 2022; Nikou & Aavakare, 2021; Anthonysamy et al., 2020; Kim, 2019). By utilizing online platforms, students can develop the ability to use technology and evaluate and use digital information critically and responsibly.

This study aims to develop students' skills, which include creative, collaborative, communicative, critical thinking, and innovation, through the integration of project-based learning and simulation in the learning process. This study attempts to integrate project-based learning and simulation models that can improve these skills. Our research contributes to the world of education by preparing future generations and can contribute to innovative learning and learning practices that are relevant to current conditions.

▪ METHOD

Participants

The population in this study was students of the mathematics education study program at Universitas PGRI Sumatera Barat who took geometry courses. In this study, sample selection was carried out through purposive sampling, which is a sampling strategy based on certain considerations or objectives (Cash et al., 2022; Klar & Leeper, 2019). Purposive sampling is used because it allows us to selectively choose samples that can represent the desired characteristics of the predetermined research objectives. By using this method, we were able to direct the sample selection to obtain relevant information within the predetermined research scope, as well as meet the desired data analysis needs. To obtain quantitative data, we conducted observations of 30 students involved in this study. Meanwhile, to obtain more in-depth qualitative data, we conducted semi-structured interviews with nine students. The selection of interview respondents was based on the variety of their academic abilities: high, medium, and low. This ability was obtained based on the results of the pretest given to students before the implementation of project-based learning and simulation. These abilities were identified based on the analysis of the results of the pre-test given to students before the implementation of project-based learning and simulation, with the aim of measuring their initial level of understanding and getting a basic overview of the competencies of the students.

Research Design and Procedures

A mixed-methods research design was used to investigate the effectiveness of integrating project-based learning and simulation on students' skills and to gain insight into how this model can increase students' skills. We integrated findings from two different approaches, namely quantitative and qualitative approaches (Creswell, 2014). Quantitative approaches focus on collecting and analyzing data in the form of numbers or statistics. Qualitative approaches emphasize in-depth understanding and description of complex contexts through data in the form of words, narratives, or descriptions (Bloomfield & Fisher, 2019). This study uses mixed methods to observe and obtain information about student skills during the implementation of project-based learning and simulation. By using mixed methods, we were able to collect detailed data while gaining an in-depth understanding of their experiences and perceptions during the implementation of the learning models used. This will help in designing more effective learning strategies that meet the needs of students in improving their skills. This mixed-methods study aims to observe and obtain information about students' skills during the implementation of project-based learning and simulation. By using mixed methods, we were able to collect detailed data while gaining an in-depth understanding of their experiences and perceptions during the implementation of the learning models used. This will help in designing more effective learning strategies that meet the needs of students in improving their skills.

The data collected was both quantitative and qualitative. Quantitative data in this study were obtained through a series of observation activities carried out systematically for five meetings. This process involves a series of activities to explore and measure information aimed at responding to the research questions that have been submitted (Kabir, 2016). Quantitative data measurement refers to the scales and criteria used to evaluate the skills that emerge during the learning process, both in numerical and descriptive form, collected through careful observation during the learning process. Meanwhile, qualitative data was obtained through the interview process. This interview was conducted in a structured and in-depth interview after all stages of project-based learning and simulation implementation were completed.

Previously, the interview process was conducted by explaining to the students that this interview was part of research that aimed to evaluate the implementation of project-based learning and simulation that they had attended. This explanation included the purpose of the research, the interview process, and the type of data that would be collected to ensure they fully understood their role and contribution as participants. As a form of consent, we asked the students to sign a letter of intent stating that they agreed to be sampled in this study freely and without pressure. In addition, we also provide a guarantee that all information they share during the interview will be kept confidential and will not be used for purposes other than this study. Through interviews, we were able to explore complexity and context from the respondents' point of view directly as well as obtain information on qualitative aspects that cannot be obtained through quantitative methods. Data were collected during project-based learning and simulation, as shown in Figure 1 below.

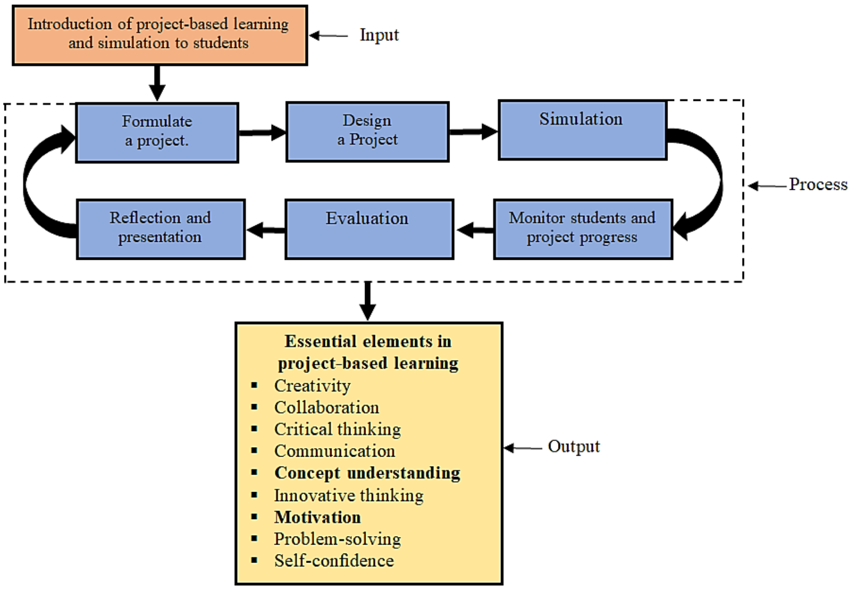

Figure 1. Steps of project-based learning and simulation (PJBLS)

Figure 1 shows a series of activities that occur during the learning process. The first step starts with the lecturer explaining to the students the implementation of project-based learning and simulation. Then, the process continues with the implementation of the steps of the learning model, which involves six stages. In this learning activity, simulation becomes an integral part integrated with project-based learning that is implemented in every meeting. Simulations are carried out by utilizing GeoGebra software as the main tool, which is used after students have completed the project design stage based on the geometry topic being studied. At each meeting, students are given 20 minutes to carry out this simulation stage, where they work according to the plan that has been designed previously in their respective groups. This simulation is designed to provide an insightful visual and interactive experience so that students can validate the geometry concepts applied in their projects directly through dynamic exploration using GeoGebra. After the simulation stage is completed, the activity continues to the next stage in accordance with the predetermined learning scenario so that each step in the learning process supports each other to achieve the goals that have been designed.

During the learning process, continuous observations are made to evaluate the development of skills that emerge during the implementation of project-based learning and simulation. Based on the literature study, nine skills can be developed through project-based learning. However, within the scope of this study, researchers limited the analysis to five skills, namely creative (Wang, 2023; Pan et al., 2023; Chang et al., 2022; Wulansari et al., 2022; Usmeldi & Amini, 2022; Rahayu & Putri, 2021; Albar & Southcott, 2021; Ummah et al., 2019; Shpeizer, 2019; Isabekov & Sadyrova, 2018; Sasson et al., 2018; Anazifa & Djukri, 2017), collaborative (Tsybulsky & Rozanov, 2023; Wulansari et al., 2022; Rupavijetra et al., 2022; Steffen et al., 2022; Lobczowski et al., 2021; Pan et al., 2021; Rahayu & Putri, 2021; Potvin et al., 2021; Martínez & Andújar, 2020; Sasson et al., 2018), communicative (Wulansari et al., 2022; Rahayu & Putri, 2021; Parrado & Sánchez, 2020), critical thinking (Wang, 2023; Suradika et al., 2023; Wulansari et al., 2022; Rahayu & Putri, 2021, Anazifa & Djukri, 2017; Holmes & Hwang, 2016), and innovative (Rahayu & Putri, 2021; Barak & Yuan, 2021; Eliana et al., 2016). The emphasis on these skills was chosen because of their role in preparing students to face real-world challenges and improving adaptability in a changing environment.

Instruments

A research instrument is a tool used to collect research data (Nassaji, 2020). In this study, the instrument used to collect quantitative data was an observation sheet. This observation sheet is used to assess student skills that appear during learning. Meanwhile, to collect qualitative data, the instrument used was a semi-structured interview sheet. This interview sheet was used to obtain information about students' views, perceptions, and experiences. To develop the observation sheet, the first step is to identify in detail the abilities that will be observed in the learning process. This identification is based on the relevant abilities to be developed or assessed through project-based learning and simulation. After the abilities to be observed are determined, the next step is to formulate specific indicators for each ability so that observations can be made in a directed and objective way. At this stage, the appropriate type of measurement scale was also chosen, namely the Likert Scale (1-4), to provide ease in analyzing the observation results. The final step is to design an observation sheet format that is simple, systematic, and easy to use by observers during the learning process.

The predefined ability indicators include five main aspects. Creativity (S1) is measured through learners' ability to provide original ideas, respond constructively to others' opinions, ask relevant questions, and design or make a visual aid. For collaboration (S2), indicators include positive interdependence between group members, active interaction in the learning process, individual responsibility for assigned tasks, and the ability to work effectively in a team. Communication indicators (S3) focus on the ability to represent certain situations through mathematical media, explain mathematical relationships, understand mathematical representations in writing, and explain mathematical narrative descriptions clearly. Meanwhile, critical thinking (S4) is assessed based on accurate interpretation, analysis, evaluation, and inference. Finally, innovative indicators (S5) include having new ideas, the ability to introduce new products, and finding new ways to innovate.

After the research instrument was designed, the next step was to conduct a pilot study with different students from other universities. The aim is to ensure the validity and reliability of the instrument before it is used in this study. Instrument validity refers to its capability to accurately measure the targeted concept or variable, as explained by Saunders et al. (2009). The data analysis process for this test was carried out using SPSS version 16.0 software. Decision-making is based on the value of Sig. (2-tailed) and Cronbach's Alpha Coefficient (α) obtained. Based on the results of the analysis that has been carried out, it can be concluded that all items on the instrument developed have proven to be valid and reliable.

Data Analysis

In this study, the quantitative data collected were analyzed by calculating the percentage. This process begins with the observer carefully noting or marking each behavior that appears on the observation sheet that has been designed. This observation sheet was based on specific indicators for each skill defined, using a Likert Scale (1-4) as the rating scale. After the observation process was completed, the raw data from each observation item was summed to obtain a raw score per subject. These raw scores were then transformed into percentage scores using the formula adopted from Hyun et al. (2020), as follows:

$$\text{Score \%} = \frac{\text{Achieved score}}{\text{Maximum score}} \times 100$$

With this formula, we can analyze and calculate the percentage of student skills. After the percentage of student skills is obtained, the next step is to compare the calculation results with the category classification (Hyun et al., 2020), which can be seen in Table 1. By referring to this classification, we can find out the extent of the level of skills possessed by students.

Table 1. Classification of the level of the student's skills

Score percentage	Conclusion	Decision
20% - 69%	Low	Failed
70% - 84%	Medium	Succeed
85% - 100%	High	Succeed

In the establishment of success standards, a threshold of 70% is used as an indicator that an individual has mastered the essential skills required. This implies an understanding of core concepts, the ability to apply basic knowledge, and the capability to perform relevant tasks according to competence (Cizek & Sternberg, 2021). The 70% mark is often considered an optimal midpoint, which functions as a differentiator between individuals who have mastered the material well and those who have not. Furthermore, this threshold becomes the minimum precondition before individuals can move on to more complex stages of learning. If the score falls below 70%, it may indicate a significant gap in knowledge or skills, potentially hindering future performance. Establishing a threshold that is too high may be unrealistic for the majority of the population and may result in disproportionate failure rates, even among individuals with sufficient understanding. Conversely, a threshold that is too low will not guarantee an adequate level of mastery.

After analyzing the quantitative data, the next step was to analyze the qualitative data. We conducted a thematic analysis to analyze the research findings with the triangulation method. Thematic analysis is one of the methods used to analyze data with the aim of finding themes through the data that has been collected (Squires, 2023). This method is very effective for identifying important themes that emerge from the data. The process began with transcribing the interview recordings carefully and completely. Next, the text was coded to identify emerging themes or patterns. Similar codes were grouped into categories or themes to facilitate analysis. Analysis was conducted to find patterns in the data. The results of the analysis were then interpreted by considering the context of the interviews, the research objectives, and relevant literature so that the findings could be given clear meaning and implications. Validation of the findings was done by referring back to the source data to ensure the consistency and validity of the analysis results. The final results were presented clearly and systematically, using direct quotes from the interviews. The final stage is reflection to evaluate the analysis process, identify obstacles or challenges, and plan steps for future research.

▪ RESULT AND DISSCUSSION

Our findings contribute to the development of student skills through the implementation of project-based learning and simulation models. In addition, this finding is also an alternative solution to developing a more effective and innovative learning model to improve student skills. The results of data analysis obtained during the implementation of project-based learning and simulation (PJBLS), showed that the average student skills in each skill aspect were in the medium and high categories. The complete analysis results are presented in Table 2. Each skill observed during the learning process was analyzed to evaluate the level of student skill achievement.

Data analysis showed that students' collaboration skills (S2) were classified in the high category, with an average score of 85. This quantitative finding was reinforced by qualitative data from the interviews, which consistently indicated that the implementation of project-based learning and simulation improved teamwork in project completion. This is due to the intrinsic nature of the PJBLS model that encourages group learning. As an illustration, two respondents, RS1 and RS3, stated that the teaching they participated in effectively developed collaboration skills. They confirm, "The learning that we carry out can develop collaboration skills because we are involved in the learning process in groups." This emphasis from RS1 and RS3 highlights the importance of collaboration skills as a key aspect of the learning process. Learning environments that involve group collaboration provide space for students to interact and facilitate the exchange of ideas, thereby directly enhancing their ability to work together. Similar perspectives were expressed by RS7 and RS24, who highlighted the role of teamwork in the success of project activities. RS7 stated, "Cooperation is the main thing in completing the task, because through collaboration we can exchange ideas." Furthermore, RS27 and RS30 emphatically emphasized that cooperation is an integral component in handling problems. They stated, "Without teamwork, we would not be able to complete the assigned tasks." This statement highlights that the effectiveness of task completion and the achievement of learning objectives are highly dependent on the team's ability to collaborate synergistically. Thus, the data shows that the PJBLS model increases individual skills and can foster a culture of teamwork.

The high category of collaboration skills is because, in PJBLS, students are required to work in groups to complete projects. This creates an environment where interaction, discussion, and task sharing are a necessity. They could not complete the project individually, thus forcing them to interact and depend on each other. Additionally, there is a positive interdependence between team members in working on the project. When they realized that each of their contributions influenced their final result, the motivation to collaborate and help one another was very high. They feel responsible for both their tasks and the team's overall performance. By collaborating, students can combine creative ideas, overcome obstacles together, and find more effective solutions than if they were working alone. They learn how to divide roles, delegate tasks, and take responsibility for their part.

Meanwhile, for other skills, students are in the medium category. It still requires further development, especially in critical thinking skills. RS3 and RS7 specifically emphasized the importance of developing this skill in supporting the success of PJBL. RS3 stated that the process of making products in such learning requires students to think critically and creatively, as confirmed by his statement, "Making a product in PJBL requires me to think critically and creatively." Meanwhile, RS2 and RS24 revealed their efforts in creating more innovative products by utilizing the various facilities available. Their experience shows that optimizing the facilities owned can encourage the creation of creative and innovative products. This experience indicates that the implementation of the PJBLS model can develop academic skills and shape students into creative individuals who are able to solve problems effectively. Additionally, RS7 and RS27 emphasized the importance of developing communication skills in this learning process. RS27 stated, "If communication in the group is lacking, then completing the task will take longer." This reflects that effective communication is key to the success of the team in completing the project.

All Students' skills except collaboration show a medium category, indicating the potential for further development. This condition means that, although students possess sufficient fundamentals, there is no optimal or consistent mastery in all aspects of these skills. One area that requires special attention is the development of critical thinking skills. The importance of developing this skill was strongly emphasized by respondents such as RS3 and RS7, who saw it as a vital element in supporting the success of PJBLS. RS3 specifically highlighted that the essence of the product creation process within the framework of PJBLS requires students to hone their critical thinking and creativity.

This medium category can also be explained by other dynamics in the learning process. Although there were efforts to innovate, as expressed by RS2 and RS24, who utilized the available facilities to create innovative products, the mastery of critical thinking for innovation has not been evenly distributed among group members. Their experiences demonstrated that optimizing facilities can stimulate creativity and innovation, but not every student achieved the same level of critical thinking during the process. This means that although the PJBLS model has been proven to develop academic skills and form creative individuals who are effective in problem-solving, the level of development for most students may not be optimal.

Communication skills were also in the medium category. RS7 and RS27 highlighted the urgency of improving communication in PJBLS. RS27's statement indicates that although students are involved in teamwork, their communication effectiveness still needs improvement. They can communicate ideas or information, but they still struggle with other aspects, such as negotiation and collaboration. This gap slows down project progress, inhibits optimal knowledge sharing, and detracts from overall team effectiveness.

Table 2. The results of the analysis of student skills through the implementation of project-based learning and simulation

Students	Score percentage					Conclusion				
	Skill									
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
RS1	95	95	90	80	90	High	High	High	Medium	High
RS2	95	95	90	90	95	High	High	High	High	High
RS3	90	95	90	95	90	High	High	High	High	High
RS4	80	80	75	70	75	Medium	Medium	Medium	Medium	Medium
RS5	90	85	90	90	90	High	High	High	High	High
RS6	85	95	90	75	95	High	High	High	Medium	High
RS7	90	95	95	80	95	High	High	High	Medium	High

RS8	70	75	65	55	70	Medium	Medium	Low	Low	Medium
RS9	70	75	70	60	70	Medium	Medium	Medium	Low	Medium
RS10	85	95	85	75	80	High	High	High	Medium	Medium
RS11	75	85	65	60	75	Medium	High	Low	Low	Medium
RS12	85	80	75	70	80	High	Medium	Medium	Medium	Medium
RS13	80	85	80	60	80	Medium	High	Medium	Low	Medium
RS14	70	80	70	65	70	Medium	Medium	Medium	Low	Medium
RS15	80	80	75	70	75	Medium	Medium	Medium	Medium	Medium
RS16	70	80	75	70	75	Medium	Medium	Medium	Medium	Medium
RS17	85	90	80	75	80	High	High	Medium	Medium	Medium
RS18	70	80	75	70	75	Medium	Medium	Medium	Medium	Medium
RS19	90	95	95	85	90	High	High	High	High	High
RS20	85	90	85	75	90	High	High	High	Medium	High
RS21	70	75	65	55	70	Medium	Medium	Low	Low	Medium
RS22	85	95	90	85	90	High	High	High	High	High
RS23	70	80	70	65	70	Medium	Medium	Medium	Low	Medium
RS24	75	80	75	70	75	Medium	Medium	Medium	Medium	Medium
RS25	75	80	70	65	75	Medium	Medium	Medium	Low	Medium
RS26	85	95	80	70	80	High	High	Medium	Medium	Medium
RS27	70	80	80	70	70	Medium	Medium	Medium	Medium	Medium
RS28	65	70	55	55	65	Low	Medium	Low	Low	Low
RS29	70	80	70	55	70	Medium	Medium	Medium	Low	Medium
RS30	70	80	80	65	70	Medium	Medium	Medium	Low	Medium
Average	**79**	**85**	**78**	**71**	**79**	**Medium**	**High**	**Medium**	**Medium**	**Medium**
Decision						**Succeed**	**Succeed**	**Succeed**	**Succeed**	**Succeed**

Table 2 shows the percentage of students' skill scores classified as S1, S2, S3, S4, and S5, along with their respective categories: high, medium, and low. In general, students have high skills, although there are still some areas that require improvement. The percentage score ranges from 55 to 95. Based on the analysis, students' skills in aspects S1, S2, and S3 achieved high scores, with most scores hovering around 90. Meanwhile, scores for S4 and S5 were lower, with some scores hovering around 70 and 80. Nonetheless, most of their skills were rated high. However, there were some exceptions to the skills possessed by respondents RS8, RS14, RS16, RS24, RS25, RS28, RS29, and RS30, which were in the medium and low categories.

Some students in the low category experienced various obstacles during this learning process. One of the main factors contributing to this is a lack of understanding of the basic concepts required to complete the project. Students often struggle to analyze problems or identify project necessities, resulting in solutions that tend to be superficial and uninnovative. They are only able to complete the task with intensive direction from the lecturer and a lack of independence in the learning process. Another contributing factor is limited technical skills, especially in using relevant technologies for simulation. Difficulty in understanding the software used causes inefficiency in processing time and reduces the quality of the final result. Low motivation was also a significant cause. Some students regarded the project as an additional task. As a result, they tend to show low engagement in every stage of learning, including creative exploration and problem-solving. On the other hand, the limited time duration of the project exacerbates the situation, as students in the low category need additional time to understand and complete complex tasks.

Observation data showed that the integration of the PJBLS model in learning encourages student participation in project implementation. Students can build their understanding and skills in learning materials through project activities. Students are actively involved in various project stages, including problem formulation, design, simulation, evaluation, and presentation of findings. This active involvement plays a role in improving their understanding of the learning material as well as their ability to apply their knowledge.

The results also revealed that the PBJLS model encourages creativity and innovation among students. With this model, students have the opportunity to think, explore, and unleash their creative potential. The use of simulation in the project-based learning framework enhances students' skill development. Students can practice making decisions, solving problems, and thinking critically. By engaging in simulations related to their projects, students can apply theoretical concepts to realistic scenarios and develop their skills. Through the combination of project-based learning and simulation, students can enhance their knowledge and develop skills that are important for their academic success. These findings highlight the positive impact of integrating the PJBLS model in empowering students to develop a variety of essential skills.

Although project-based learning and simulation have great potential in encouraging the development of student skills, their implementation generally only enables the development of these skills to a medium level, such as creativity, critical thinking, communication, and innovation. This is due to several inhibiting factors when implementing these learning models. One of the main obstacles is the limited time duration of the project. Students do not have enough to explore problems in detail, explore alternative solutions, or develop their creative ideas into innovative products. Under these conditions, they tend to focus on the results of projects without paying attention to the process, which involves critical analysis and deep reflection.

In addition, limited facilities and technical support are other significant factors. Many students face difficulties in utilizing available technology for simulation due to their limited skills in using it. As a result, the simulations conducted are suboptimal and serve only as a simple tool rather than a means for creative exploration or complex innovation. On the other hand, students' communication skills are often limited to basic discussions, with minimal to no development of collaboration skills, such as negotiation or conflict management within teams. Students' intrinsic motivation also plays an important role. Some students perceived the project as merely an academic task to be completed rather than an opportunity to develop skills relevant to the world of work. Additionally, the lack of systematic reflection after project completion deprives students of the opportunity to learn from their mistakes or refine their strategies in subsequent projects.

PJBLS has provided diverse learning experiences for students with different academic ability levels. RS2, who belongs to the high-ability group, revealed that this learning encouraged him to think more critically in creating a product. This demonstrates how the activity challenges her intellectually to devise innovative solutions. On the other hand, RS7, who has a medium academic ability level, felt that this learning allowed him to hone his analysis, planning, and decision-making skills. This statement indicates the effect of learning on his systematic thinking skills. Meanwhile, RS30, who has a low academic ability level, suggested that this approach succeeded in increasing his curiosity, thereby motivating him to think more about completing the given task. From all three perspectives, despite their different ability levels, all subjects experienced similar benefits in terms of developing critical thinking skills. This shows that project-based learning and simulation can create an inclusive and adaptive learning environment where students from diverse ability backgrounds can experience a positive impact. Even for students with low academic ability, such as RS30, this learning experience was able to build confidence and drive to improve, which may not have been previously apparent. This is evidence that this learning model not only targets cognitive enhancement but also affective aspects, which contribute to the development of 21st-century skills.

The results of the study showing that the integration of project-based learning and simulation models has been proven to have a positive impact on student skills are consistent with previous studies, which found that project-based learning can improve collaboration skills, problem-solving (Yusri et al., 2024; Sarwi et al., 2021; Chen & Chang, 2021), and student creativity (Ummah et al., 2019; Hanif et al., 2019; Yusri et al., 2019). Although their research shows that project-based learning is effective in increasing collaboration skills and creativity, the addition of the simulation element in this study brought a new dimension to the learning experience. Simulation allows students to test their creative ideas in a virtual environment. Simulation provides an opportunity for students to evaluate and modify their ideas based on the simulation results, an element that is not present in PJBL. Through simulation, students can accelerate the process of exploring ideas, understand the consequences of their decisions, and develop more innovative solutions. In addition, although the level of student creativity only reached the "medium" category, the integration of simulation contributed to supporting project-based learning. Simulations not only complement PJBL with concrete visual representations but also reinforce the learning process through hands-on experiences that closely resemble reality. Additionally, this approach enhances students' confidence in expressing new ideas, as they have the opportunity to test and validate their thoughts. Through project activities in PJBLS, students are involved in projects that require teamwork to work together, solve problems, and produce solutions.

The study conducted by Lee et al. (2020) also found that PJBL contributes to improving students' communication skills and critical thinking skills. In the learning process of PJBL, students are faced with situations that require them to convey ideas, argue, and formulate solutions logically and critically. Students can hone their communication skills and improve their ability to analyze problems more deeply. This can strengthen their ownership of the learning process, increase their motivation (Yusri et al., 2024) to take initiative, and improve the quality of learning (Yusof et al., 2024). In addition, other studies have also highlighted that simulation in learning can strengthen practical skills relevant to the world of work (Campos et al., 2020; Ornellas et al., 2019). Through simulation, students are allowed to practice making decisions, managing learning, and dealing with the challenges they face. Thus, the use of simulation in project-based learning can enhance conceptual understanding and prepare students with skills that can be applied directly to the workplace.

The data also shows that the implementation of the PJBLS model stimulates student creativity and innovation in the learning process. The results of a study conducted by Wang (2023) showed that project-based learning can inspire students to think critically and explore their potential creativity. Another study conducted by Pan et al. (2003) also found that project-based learning provides opportunities for students to explore various alternative solutions and provides a sense of ownership of the learning process. Furthermore, study findings highlight that the use of simulation can enhance students' skill development, including decision-making, problem-solving, and critical thinking abilities (Simanjuntak et al., 2021; Chang et al., 2020).

In addition, the results of our study also show that the integration of the PJBLS model can improve teamwork in completing a project because the process is carried out collaboratively in groups. This finding is in line with research conducted by Tsybulsky & Rozanov (2023), which revealed that the PJBL model can improve students' cooperation skills. For example, RS1 and RS3 consistently highlighted that their learning experience was in working together, which became an important aspect of the learning process. The study by Rupavijetra et al. (2022) also supports this by finding that collaborative learning in groups can expand conceptual understanding and develop ideas through social interaction. Similarly, RS7 and RS24 emphasized the importance of teamwork in project activities.

The study conducted by Martínez and Andújar (2020) also supports these findings by showing that collaboration in teams can increase productivity and effectiveness in completing tasks. RS7 explained that cooperation is an essential aspect of completing tasks, as through collaboration, they can exchange ideas. Likewise, RS27 and RS30 emphasized that cooperation is an important part of dealing with problems. The study conducted by Sasson et al. (2018) also showed that teamwork can accelerate the identification and solution of problems faced, where without teamwork, they would not be able to complete the assigned tasks. In this context, collaboration between students in the PES model is key to achieving optimal results. Through cooperation, students provide support to each other and generate new ideas. This enables them to overcome learning challenges. Collaboration skills can also strengthen social interactions among students, thus preparing them to become positive and productive contributing members (Barak & Yuan, 2021; Eliana et al., 2016).

RS7 and RS27 revealed that the PJBLS model, which emphasized group work, was able to improve their communication skills. This is supported by studies showing that project-based learning can improve students' interpersonal communication skills (Wulansari et al., 2022; Crespí et al., 2022). Furthermore, research conducted by Rahayu and Putri (2021) found that group work can improve students' communication skills as well as broaden their understanding. In this context, RS27's statement, "If communication in the group is lacking, then completing the task will take longer," supports these findings. Supporting data from previous studies reinforces the importance of communication skills in enhancing the effectiveness of project-based learning and simulation. Therefore, the findings from the previous set of studies consistently support the integration of project-based learning and simulation in equipping students with the necessary skills to achieve academic success.

▪ CONCLUSION

In conclusion, the integration of project-based learning and simulation proved to have a positive impact on students' skill development. In terms of collaboration skills, this approach achieved a high category level, demonstrating its effectiveness in fostering solid and productive teamwork. Meanwhile, other skills, such as creativity, communication, critical thinking, and innovation, are classified into the medium category. This suggests that while the integration of PJBLS has contributed to supporting the development of these skills, there is still room for further improvement in its effectiveness. The results of this study fill the gaps that exist in the research. Through project activities in PJBLS, students are involved in situations that allow them to learn together and produce solutions. The ability to work together in teams can help them complete project tasks effectively. Collaboration between students increases interaction and strengthens interpersonal skills when solving problems. Communication skills are also one of the important aspects of the PJBLS model, where group work in learning can improve students' communication skills. The implementation of the PJBLS model also encourages students' creativity, critical thinking, and innovation in the learning process, opens up space for exploration, and provides a sense of ownership of learning. The integration of PJBLS is not only effective in increasing students’ skills but also relevant for facing complex challenges, such as the ability to analyze information, systematically identify problems, and find innovative solutions. Additionally, this approach indirectly helps overcome the challenges of digital literacy and technological skills by familiarizing students with digital devices and simulation applications during the learning process. Thus, the integration of PJBLS is not just a pedagogical strategy but an essential framework that prepares graduates to become individuals who are not only knowledgeable but also skilled, adaptive, and ready to collaborate in facing the complexity of future challenges.

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