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TRANSFORMING MATHEMATICS LEARNING: IMPROVING STUDENT MOTIVATION BY INTEGRATING PROJECT-BASED LEARNING AND SIMULATION

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Abstract:

The a lack of study that examines the combination of these two methods in learning Geometry, especially in terms of its effect on student learning motivation, this study is here to answer this need. The purpose of this study is to determine the extent to which the integration of project-based learning and simulation can increase student learning motivation. This study is a quantitative research with A group pre-test and post-test design. This study involved thirty students of Universitas PGRI Sumatera Barat, Indonesia. Data collection was done through questionnaire. Data analysis was conducted with One-way ANOVA. The results showed that students who studied using the integration of project-based learning and simulation had a significant level of learning motivation. Students felt more engaged and academically challenged, which contributed to their increased motivation. This study concludes that the integration of project-based learning and simulation in mathematics learning is effective in increasing students' learning motivation. The findings provide practical implications for educators in designing more innovative and effective learning strategies to improve the quality of mathematics education at the tertiary level. Further research is recommended to explore the impact of the integration of this learning model on other skills and examine its applicability in other disciplines.

Keywords:

Project-Based Learning, Simulation, Learning Motivation, Geometry, Higher Education

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Introduction

Learning motivation contributes to students' academic success in higher education (Pedler et al., 2022). Strong motivation can encourage students to be more actively involved in the learning process, improve their ability to face various academic challenges and motivate them to achieve higher. Students with high learning motivation tend to show greater interest in learning, participate more actively in discussions, and develop more effective learning strategies, which ultimately contribute to the achievement of optimal academic results. The study shows that highly motivated students tend to have better academic performance and higher academic achievement. They also have higher attendance rates, demonstrating a strong commitment to attend learning and other academic activities consistently. In addition, highly motivated students feel more satisfied with their learning experience, as they are more actively involved in the learning process, find meaning and satisfaction in academic activities, and feel greater personal accomplishment in their learning journey (Ferrer et al., 2022).

Survey data shows that 79% of respondents stated that motivation is the main factor that drives them to achieve high academic performance (Anderson et al., 2018). This finding indicates that most students consider motivation, both intrinsic and extrinsic, as the main driver in their efforts to achieve good grades, complete assignments optimally, and overcome the academic challenges they face. In addition, the study by Dörnyei and Muir (2019) found that providing constructive feedback and a supportive learning environment significantly increased students' learning motivation. Their results showed that when students received clear, specific, and constructive feedback, their intrinsic motivation to learn increased as they felt valued and guided in their learning process. In addition, a supportive learning environment also plays an important role in maintaining and enhancing students' learning motivation, allowing them to be more passionate and enthusiastic in achieving their academic goals. Thus, student motivation to learn becomes very important for higher education institutions to improve the quality of learning and academic success.

One of the challenges often faced in encouraging students' motivation to learn is the low level of intrinsic involvement in the learning process, where students do not feel actively encouraged in learning activities because of their interest and pleasure (Chaudhuri, 2020). Many students show more extrinsic motivation, where they learn to achieve high grades or other external rewards. A study conducted by Firat et al. (2018) showed that students with high intrinsic motivation tend to have better learning outcomes compared to those motivated by extrinsic factors. Thus, low intrinsic engagement can result in a lack of active participation in learning and, a lack of initiative to understand the material, and ultimately hurt academic achievement.

Another issue related to student motivation is the high level of academic stress (Heo & Han, 2018). This stress is often triggered by heavy workloads, pressure to achieve high academic standards, and the challenge of balancing studies and personal life. The negative impact of academic stress can inhibit students' motivation to study optimally. It even has the potential to reduce the academic results achieved. The study conducted by Adom et al. (2020) revealed that excessive academic stress can cause mental health disorders such as anxiety, which can reduce learning motivation and academic achievement. Students report that stress has negatively impacted their ability to learn and achieve their academic goals (Frazier et al., 2020). Therefore, high levels of academic stress are one of the challenges that affect learning motivation.

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Previous study has also highlighted the role of social support in shaping students' learning motivation (Mishra, 2020). Students who feel strong support tend to have higher levels of learning motivation and help students overcome academic challenges and maintain their motivation during learning. These findings consistently confirm that social support factors have a non-ignorable influence in creating a supportive learning environment and motivating students to achieve their optimal academic potential. Students who feel they have social support are better able to overcome obstacles in the learning process. Conversely, a lack of social support can lead to low self-confidence, and decreased motivation to learn.

To overcome the problems that occur, one of the efforts that can be made is the integration of project-based learning and simulation in learning. This approach allows students to engage in real projects that are relevant to their interests and needs, so they feel more motivated to learn because of the connection between the subject matter and everyday life. Wijnia et al. (2024) showed that project-based learning can increase students' motivation as it provides a meaningful context for their learning. In addition, project-based learning has been proven to encourage collaboration, problem-solving, and the development of critical thinking skills, all of which contribute to increased student engagement (Karan & Brown, 2022; Viswambaran & Shafeek, 2019). This approach also creates a more dynamic and interactive learning environment, allowing students to put theory into practice through hands-on experience. Through this approach, it is expected that students will be more motivated to learn with interest and pleasure that comes from within themselves, to achieve more optimal learning outcomes. Thus, the integration of project-based learning and simulation can increase student motivation and engagement, and support the development of skills needed in the real world.

Literature Review

Project-Based Learning

Project-based learning (PJBL) is a learning model where students learn through projects that require them to apply the knowledge and skills they learn in a real context (Markula & Aksela, 2022). In project-based learning, students work together in groups to solve projects that usually involve research, collaboration, and presentation. PJBL engages students in complex and challenging projects that encourage them to learn and apply knowledge. This method has proven to be effective in increasing student engagement, critical thinking skills, and problem-solving ability. In a study conducted by Li et al. (2019), it was found that students who engaged in PJBL showed significant improvements in concept understanding and analytical skills compared to those who followed conventional learning.

One of the theories founding the effectiveness of PJBL is the theory of constructivism introduced by Piaget and Vygotsky. Piaget stated that learning is an active process in which students construct their knowledge through interaction with the environment (Waite-Stupiansky, 2022; Devi, 2019). Vygotsky added that learning occurs socially, and collaboration with peers and facilitators can accelerate cognitive development (Wald & Harland, 2022). PJBL, by emphasizing contextual and collaborative learning, aligns with these principles and provides an environment that supports in-depth knowledge construction. In addition, empirical evidence also shows significant benefits of PJBL in various disciplines. For example, a study by Hajian (2019) showed that students who learned mathematics through projects demonstrated deeper understanding and better knowledge transfer ability compared to students who learned through traditional methods. This data was supported by Miller and Krajcik

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(2019), who found that PJBL improved conceptual understanding and helped students develop their metacognitive skills.

Thus, project-based learning is an effective learning approach in education. Grounded in constructivism theory and supported by strong empirical evidence, PJBL is an innovative and effective approach to improving student engagement, concept understanding, and critical thinking skills. The implementation of PJBL in various learning contexts can contribute significantly to improving student learning and the quality of education.

Simulation

Simulation methods have been a significant innovation in learning, providing new ways for students to understand complex concepts. Simulation enables visual and interactive representations of complex problems, allowing students to observe the dynamics of change and understand the relationships between variables in greater depth. According to research conducted by Fallon (2019), the use of simulation methods in learning shows a significant improvement in the understanding of basic concepts compared to conventional methods. This is supported by the findings of Chernikova et al. (2020), who stated that interactive simulations assist students in developing a better understanding of concepts through direct experience. Furthermore, simulation methods provide a safe learning environment for experimentation, which is very important in learning mathematics that often involves abstract concepts and complex calculations (Hillmayr et al., 2020). They found that the use of computer simulations in mathematics teaching can improve students' problem-solving skills, and increase their learning motivation. Data from this study showed that students who learned by using simulations obtained higher scores in concept understanding tests compared to students who learned through traditional methods.

Simulation also enables the integration of technology in learning, which is in line with the times and the needs of students. O'Flaherty and Costabile (2020) noted that students who engaged in simulation showed improvements in their engagement, confidence, and critical thinking. In terms of learning theory, the simulation method is also in line with the theory of constructivism pioneered by Piaget and Vygotsky, where students learn more effectively through direct experience and interaction with their learning environment. This method provides opportunities for students to construct their knowledge through exploration and experimentation, which is very important in learning mathematics which often demands an in-depth and analytical understanding of concepts. Thus, the simulation method in learning can improve students' concept understanding and problem-solving skills, as well as support the development of learning motivation and 21st-century skills that are very important in the digital era.

Learning Motivation

Learning motivation is an important aspect of the educational process that has been widely researched. According to the self-determination theory of motivation proposed by Ryan and Deci. (2020), intrinsic and extrinsic motivation play a key role in determining the extent to which students commit to the learning process. Intrinsic motivation refers to the drive that comes from within the student, such as curiosity and enjoyment of learning, while extrinsic motivation is triggered by external factors such as rewards or recognition (Ryan & Deci., 2020). The study by Karlen et al. (2019) showed that intrinsically motivated students tend to have

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better academic performance and are more resilient in the face of academic challenges compared to those who are only extrinsically motivated.

Studies have also highlighted the importance of learning strategies that can increase students' intrinsic motivation (Lepper & Malone, 2021; Alamri et al., 2020). Their study noted that students who can manage their learning process will be more motivated to achieve their academic goals. On the other hand, extrinsic motivation also has an important role, especially in the context of formal education where assessment and rewards are an integral part of the system. According to a study by Ryan and Deci (2020), although extrinsic motivation is often considered less ideal than intrinsic motivation, a combination of both can produce optimal learning outcomes if applied appropriately. For example, rewards given for specific achievements can strengthen intrinsic motivation if they are integrated with recognition of student effort and progress. Understanding and managing different types of learning motivation is key to improving students' academic performance. A balanced approach between intrinsic and extrinsic motivation, as well as the use of effective learning strategies, can create a supportive and effective learning environment.

Research Methodology

This study uses a quantitative method with a one-group pre-test and post-test research design. Quantitative methods are used to analyse numerical data, as explained by Bloomfield & Fisher (2019), and utilize statistical tools to test previously established hypotheses. In this study, the quantitative method uses a quasi-experimental approach that allows researchers to measure and analyse the effect of certain learning models on the variables being investigated. This approach provides an opportunity to obtain empirical data so that the results of the study can make a significant contribution to understanding the effectiveness of the implemented learning model.

Data collection is an essential part of each study. This stage involves collecting and measuring the information needed to answer research questions (Kabir, 2016). In this study, quantitative data were obtained through questionnaires distributed before and after the implementation of the learning model, aiming to get an overview of student motivation. This questionnaire was chosen as a research instrument to collect quantitative data related to student learning motivation. By using this instrument, researchers can measure variables related to learning motivation, so that statistical analysis can be conducted.

Once the data is collected, the next step is to check the completeness of the data and perform a recapitulation. After this stage was completed, the data was analysed using SPSS software. Data analysis was conducted using the t-test, namely the One-way ANOVA test, to identify differences in student learning motivation before and after treatment. Before carrying out the ANOVA test, the normality and homogeneity of the data were tested first. The decision was made by comparing the significance value (Sig) obtained with the predetermined significance level ($\alpha = 0.05$).

Data Analysis

The results of the analysis show that there is a significant difference between the average score of students learning motivation before and after implementing project-based learning and simulation. To see the difference, firstly, the analysis requirement test was conducted which includes the normality test and homogeneity test. Test the normality of student learning motivation data using the Kolmogorov-Smirnov test. The test criteria is to accept H_0 if the

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value of Sig. > significant level ($\alpha = 0.05$) and reject H_0 otherwise. The results of the normality test can be seen in Table 1.

Table 1. Tests of Normality

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Score	Pre-Questionnaire	.139	30	.143	.967	30	.453
	Post-Questionnaire	.121	30	.200*	.927	30	.040

Table 1 shows that the Sig. Value of students' learning motivation has a sig. Value greater than the significant level ($\alpha = 0.05$) which indicates that student learning motivation data is normally distributed. Meanwhile, the homogeneity test of the variance of student learning motivation data using the Levene test. The test criteria is to accept H_0 if the Sig value. > significant level ($\alpha = 0.05$) and reject H_0 otherwise. The results of the homogeneity test can be seen in Table 2.

Table 2. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.177	1	58	.675

Table 2 shows that the Sig. Value of student learning motivation has a Sig. Value greater than the significant level ($\alpha = 0.05$) which is 0.675 which indicates that students' learning motivation data has a homogeneous variance. Because the learning motivation data is normally distributed and has a homogeneous variance, then the t-test is carried out using the One-way ANOVA test to see the average score difference in students learning motivation data. The analysis results are presented in Table 3.

Table 3. Tests of ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2535.000	1	2535.000	9.818	.003
Within Groups	14975.933	58	258.206		
Total	17510.933	59			

Table 3 shows a significant difference between the two data groups, with a significance value (Sig.) of 0.003. This number is smaller than the predetermined significance level ($\alpha = 0.05$), indicating that the observed difference has strong statistical significance. In addition, the F value obtained from the ANOVA test is 9.818, which corroborates the conclusion that there is a considerable difference between the two groups in terms of learning motivation. This high F value indicates that the variability between groups is much greater than the variability within each group, thus supporting the hypothesis that the treatments have a significant effect on students' learning motivation. This analysis proves that project-based learning and simulation have a positive and significant impact on students' learning motivation. This underscores the importance of using the right learning approach to increase students' learning motivation.

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Discussion

The finding that there is a significant difference in the learning motivation of students who received project-based learning and simulation treatment is in line with several theories and results of previous studies. Self-determination theory remains an important foundation for understanding learning motivation (Luria et al., 2021; Ryan & Deci., 2020; Sheldon & Prentice, 2019; Hsu et al., 2019). However, recent studies have broadened and deepened the understanding of how learning environments can influence students' intrinsic motivation. Vidergor (2022) found that motivational theory-based interventions, such as project-based learning, have a positive effect on student learning outcomes. This finding strengthens the argument that learning approaches that support students' basic psychological needs can significantly improve their learning motivation. Furthermore, a study conducted by Owens et al. (2020) explored the effect of student engagement in learning on learning motivation. They found that when students were involved in the learning process, their motivation and ownership of their learning increased significantly. This finding strengthens the argument that learning approaches that give students autonomy can increase learning motivation.

This study also corroborates previous findings that project-based learning can increase student engagement (Juuti et al., 2021; Viswambaran & Shafeek, 2019; Yusri et al., 2019) and motivation (Hira & Anderson, 2021) through more relevant and meaningful learning experiences. According to the social constructivism theory proposed by Vygotsky, effective learning occurs when students are actively involved in constructing knowledge through social interaction and direct experience (Taber, 2020). Project-based learning is aligned with this principle, providing opportunities for students to apply knowledge in a real and meaningful context. This result is supported by qualitative research conducted by Chen et al. (2019), which revealed that students reported higher levels of engagement and relevance of learning when participating in collaborative projects.

Although most studies show positive results, some studies also identify challenges in the implementation of project-based learning. Research by Kokotsaki et al. (2022) revealed that the effectiveness of project-based learning largely depends on the quality of teacher support and careful project design (Yusof et al., 2024; Haatainen & Aksela, 2021; Isa & Azid, 2021; Pan et al., 2021; Hafizah et al., 2018). These findings emphasize the importance of teacher professional development and good lesson planning to maximize the benefits of project-based learning.

Related to simulation, the study of Makransky et al. (2020) found that simulations have positive effects on student interest and performance, especially when simulations are designed to support student autonomy and competence. They emphasized the importance of designing simulations that provide meaningful feedback and opportunities for reflection. A well-designed learning environment that supports students' basic psychological needs can increase their motivation (Zhou et al., 2019). These findings highlight the importance of project-based learning and well-designed simulations, in creating an optimal learning environment. Learning approaches that support students' autonomy, competencies, and needs significantly increase student motivation and engagement (Wang et al., 2019; Alley, 2019). This suggests that the principles underlying the effectiveness of project-based learning and simulation in enhancing learning motivation can be effectively applied to learning.

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Conclusions

The results of this study show the effectiveness of project-based learning and simulation in increasing students' learning motivation. The main finding shows a significant difference in the learning motivation of students who follow project-based learning and simulation. The increase in motivation is closely related to the application of relevant real contexts in learning, as well as the encouragement to collaborate between students. However, it should be noted that the successful implementation of project-based learning and simulation also depends on proper support and carefully designed projects to achieve optimal results. In conclusion, this study confirms that project-based learning and simulation have great potential in changing higher education for the better. By implementing these approaches, higher education can create a more dynamic, relevant, and motivating learning environment that better prepares students for real-world challenges.

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