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Enhancing Creative Thinking Skills and Student Achievement: An Innovative Approach through Integrating Project-Based Learning in STEAM and Self-Efficacy

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Abstract

Students are required to be able to think creatively to support optimal student achievement. However, empirical evidence suggests that creative thinking skills and student achievement still need improvement and must be addressed. This study compares the project learning model STEAM to direct learning STEAM as a learning step and academic self-efficacy to encourage creative thinking skills and learning achievement. A quasi-experimental pretest-post-test non-equivalent control group design was used in the research's approach. One hundred fifty students from Bali's higher-degree Informatics Engineering study program attended the study. MANCOVA was used to analyze the data. The outcomes demonstrated that 1) There is a significant difference between the students who learn using the project STEAM and Direct-STEAM, where the group of students who learn with the project STEAM is superior. 2) Differences in academic self-efficacy affect students' creative thinking skills and learning accomplishment, with students with high academic self-efficacy having higher learning achievement and creative thinking skills than students with low academic self-efficacy. 3) the model's interaction with academic self-efficacy and project STEAM does not influence students' creative thinking skills and learning achievement. Regarding the research findings, the project-STEAM learning model can be applied to increase learning outcomes and abilities in computer architecture materials.

Keywords: project-based learning STEAM, self-efficacy academic, creative thinking skills, student achievements.

Introduction

Learning is essential in supporting the development of the quality of education (Santyasa, Santyadiputra, & Juniantari, 2019). Research from Chusni et al. (2022)discovery-based learning and student-centered activities may be beneficial. This study aims at investigating: (1 explains that optimal learning occurs when students can build their knowledge concepts through activities around them. The development of education has entered a new phase since the COVID-19 pandemic. During the pandemic, lessons can be learned using technology, learning methods, and strategies to maintain student learning activities (Djudin, 2020; Ekayana, 2022)the independent t-test, and the extent of readiness was interpreted according to the interval of the overall average score. Based on data analysis, it is found that the total profile of "never and seldom" teachers' responses is 9.2%, the "often and always" is 20.0%, and "sometimes" is 70.8%. There is no total means score difference between experienced and novice teachers' performance (t = 0.887, p > 0.05. Learning innovation needs to be prepared to face the new post-pandemic era, which plays a role in building the quality of students to develop century skills 21 (Simanjuntak, Hutahaean, Marpaung, & Ramadhani, 2021). Furthermore, the challenge for educators in the 21st Century is that learning is no longer content-based or understanding facts but has changed to skill development, knowledge management, and character building (Suryaningsih & Ainun Nisa, 2021).

Computer Architecture (next: CA) is a crucial lecture material for students to understand to support competency development in the 21st Century (Nayak, Hiremath, Umadevi, & Garagad, 2021). CA is part of the exact sciences that explore the concept of planning, how to work, and the primary operating structure of components in computer systems. The

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problems in CA learning in higher education are still oriented towards material completeness and lack of activities that encourage problem-solving, impacting meaningless learning (Sidek, Yatim, Ariffin, & Nurzid, 2020; Suhaimi, Rosli, Ariffin, Muniandy, & Wahab, 2019)the world has experienced four educational revolutions, which have drastically changed the educational landscape as we know it. Today, the fourth (4th.. As a result, many students are good at assembling computer components but need to improve their analysis and creativity. To attain these skills, students must possess critical and innovative thinking capacity. If merely relying on traditional learning methods or rotary memorization is insufficient (Suhaimi et al., 2019; Sulistianingsih & Dalu, 2021)the world has experienced four educational revolutions, which have drastically changed the educational landscape as we know it. Today, the fourth (4th.. Limited meeting learning time does not support the scope of CA material, making it difficult for teachers to provide activities outside the classroom. Based on preliminary studies, CA learning in universities tends to use Direct Learning in the classroom and online learning. The use of old ways in the learning process affects student activeness in learning and tends to train less creative thinking skills in solving real-world problems.

Research results (Pratiwi & Santyasa, 2021) also showed that the provision of material and the evaluation of learning using the direct learning model tend to be low-level reasoning activities, respectively (LOTS). Research results Sigit et al. (2022) explain that using direct learning models has relatively little *impact* on learning outcomes because it tends to be rote-based and does not support students' confidence levels in demonstrating learning material. However, despite increasing attention, 21st-century learning competencies still need to be more effective. Shows that there is still a gap between the standard of the learning process and student learning outcomes. In addition, entering the post-pandemic period, it is estimated that learning activities have undergone many changes that have led to the use of specific technologies and applications in learning (Agustini, Pratiwi, Mertayasa, Wahyuni, & Wedanthi, 2021). Given the facts and data above, higher education must modify its structure and method of instruction to enhance students' achievement and foster their capacity for creative thought (HOTS).

Various educational technology researchers have been trying to combine and include various learning models, including inquiry models, PBL, STEM, PjBL, and discovery learning. According to Santyasa et al. (2021)or 81.1% of the population, research findings indicate that blending the PjBL learning paradigm with e-learning improves students' critical thinking skills and learning performance throughout the pandemic. Research conducted (Atmojo, Ardiansyah, & Saputri, 2022) about using discovery learning models in entrepreneurial subjects can improve ecopreneur critical thinking, communication, and creativity skills. Therefore, this study tries to apply a Project-based Learning model integrated with STEAM (next; Project-STEAM). Integrating Project-STEAM is an innovative step in using technology as a learning model by involving aspects that support students' creative thinking skills and learning achievement (Lin, Wu, Hsu, & Williams, 2021). Changes in the dynamics of education began to focus on the indicators needed in learning activities, and it was possible to integrate the STEAM project into learning practices (Rahmania, 2021). Each student in the learning activity is instinctively involved in problem-solving. According to research, the Project-STEAM approach or *"learning by doing"* based on constructivist theory can encourage students' ability to solve problems naturally (Laboy-Rush, 2007), which has been shown to improve learning achievements in high-level thinking skills (HOTS) (Guo, Saab, Post, & Admiraal, 2020), such as scientific concepts and problem-solving in the fields of science, technology, engineering, and mathematics (Santyasa et al., 2021)or 81.1% of the population. Studies on combining STEAM approaches with project-based learning have been accomplished by (Sigit et al., 2022). This research reveals that the PjBL STEAM model can increase mastery of ecological concepts and encourage students to think exploratorily, creatively, and problem-solve.

For this reason, STEAM needs to be combined with a model that supports project activities in learning so that students can create relationships between the material and the world around them. PjBL is a suitable model to collaborate with the STEAM approach, where this model is project-based (Almulla, 2020), supports the exploration of the surrounding environment, and builds meaningful learning through learning by doing (Ferrero, Vadillo, & León, 2021; Laboy-Rush, 2007). Research results (Randazzo, Priefer, & Khamis-Dakwar, 2021) show that project-oriented learning (PjBL) builds student initiative to be directly involved in learning, builds motivation to learn and practice demonstration techniques, is more sensitive to the surrounding environment, supports cognitive development of creative thinking and critical thinking, and increases student confidence.In addition to external factors of students, factors from within students affect students' learning outcomes and thinking skills, including motivation, procrastination, intelligence, self-confidence, environment, and attention. In this study, the factors studied were academic self-efficacy. According to (Hwang, 2020)a study examining mediating factors on the relationship between PD and student-centered instruction is of great importance in enhancing the effectiveness of PD and shifting teacher practice. Although studies examining the mediating effects of contextual factors (e.g., administrative support, self-efficacy is an inspiring factor that impacts a person's faith in one's capacity to provide the desired outcomes in the learning process (Bandura, Freeman, & Lightsey, 1999). In line with the study's results, Capron Puozzo & Audrin (2021) express that increased self-confidence affects students' motivation and enthusiasm for learning initiatives to submit opinions, provide explanations, and demonstrate projects. Research results from Djatmika et al. (2022) revealed a significant relationship between thinking patterns and self-efficacy (Bandura et al., 1999). Students' academic self-efficacy factors encourage them to show the best ability to generate ideas, think initiative, and self-confidence; generally, the self-efficacy level affects the development of mindsets (Nauvalia, 2021).

The development of student potential in creative thinking must be supported by suitable learning methods and strategies (Santyasa et al., 2019; Sigit et al., 2022; Suryaningsih & Ainun Nisa, 2021). The results of literature and research reveal that the STEAM approach collaborated with the PjBL learning model can increase learning achievement learning effectiveness, support students to interpret a material with concepts in the surrounding environment, better creative and critical thinking skills, support initiatives in problem-solving (Chung, Huang, Cheng, & Lou, 2020; Randazzo et al., 2021). Previous research revealed that the PjBL model can improve learning outcomes in collaboration with the STEAM approach. However, this has not been widely implemented for ICT students with the addition of moderator variables, namely academic self-efficacy as a group sorter. The effect of the Project-STEAM learning model and academic self-efficacy applied to computer architecture learning on creative thinking skills and learning expectations has not yet been revealed. Therefore, this study examines project-STEAM and academic self-efficacy applied to computer architecture learning on creative thinking skills and learning predation in higher education.

Method

Research Design

This research is quasi-experimental by applying the project STEAM model in experimental classes compared to direct STEAM models in control classes. This study seeks to reveal differences or causal relationships from changes in independent variables to dependent variables. In pseudo-experimental research, not all student variables can be controlled, so they only hold the learning model and are accompanied by moderator variables, namely academic self-efficacy. However, by using the proper research methods, the results of this research can be scientifically accounted for (Table 1).

Table 1: Research Design

Learning Model (A) *Self-efficacy (B)*	*Model Project STEAM (A_1)*	*Model Direct STEAM (A_2)*
High (B_1)	$Y1(A_1B_1)$,$Y2(A_1B_1)$,	$Y1(A_2B_1)$, $Y2(A_2B_1)$
Low (B_2)	$Y1(A_1B_2)$, $Y2(A_1B_2)$,	$Y1(A_2B_2)$, $Y2(A_2B_2)$

Population and Sample

This study included ten classes (260 students) of first-year learners in a course of study in Informatics Engineering. Statistically, the ten classes are homogeneous because each type is determined randomly at formation. Therefore, each class can be taken as a sample, so six classes were defined as samples through the group random sampling method, with as many as 150 students as samples. The six classes were divided into experimental classes using the Project-STEAM learning model and control classes using Direct STEAM. The practical and control classes are divided into two categories: students with high academic self-efficacy (HASE) and those with low academic self-efficacy (LASE).

Data Collection Tools

Research instruments are tools researchers use to collect data from research activities to be analysed further. In this study, academic self-efficacy variables were measured using a questionnaire instrument with 44 items. Creative thinking skills are calculated using an essay test of 10 points, and student achievement using a multiple-choice test with a total of 15 test points.

Academic self-efficacy is one of the internal factors contributing to students' learning success (Oppermann & Lazarides, 2021). Developing students' self-efficacy encourages cognitive structure, self-emotional management, and learning independence (Choi, Lee, & Kim, 2019). Some literature highlights that the influence of self-efficacy can form patterns of creative initiative, and tend to be willing to be involved in solving tasks in groups. Table 2 depicts the elements of academic self-efficacy.

The activity of discovery, giving birth to new ideas, and solving a project is closely related to the ability to think

Table 2: Dimensions of Academic Self-efficacy

Elements	*Indicators*
Difficulty Level	Confidence in solving a learning problem
Confidence Level	Confidence in self-potential in completing learning tasks
Breadth Level	Attitudes that demonstrate confidence in learning

creatively, which involves several components: fluency, flexibility, flexibility, and elaboration (Ozkan & Umdu Topsakal, 2021; Yildiz & Guler Yildiz, 2021). Table 3 displays the various aspects of creative thinking skills.

Student achievement is the estuary of learning activities students have carried out (Hasri, 2021). Student achievement is synonymous with giving values or numbers to a learning activity (Santyasa et al., 2019). Computer architecture student achievement is measured using multiple-choice tests. The items on the test are adjusted to the student achievement and Bloom's taxonomy so that the competence of overall computer architecture student achievement can be measured. Indicators of learning outcomes are shown in Table 4.

Table 3: Dimensions of Creative Thinking Skills

Creative Thinking Skills	*Indicators*
Fluency	Presentation of opinions with new ideas; Troubleshooting with new solutions
Elaboration	Development of initiative in learning; Ability to explore new information
Flexibility	Answer in different ways; Ability to ask further questions
Originality	Thorough explanation of responses; Explanation of the understanding of the main points of the material

Table 4: Computer Architecture Learning Achievements

Expected Final Capabilities	Indicator	Cognitive Domain
Students can use natural science, mathematics, engineering principles, and engineering science to design BUS and PCI system components, interconnection structures, and interconnections in computer system design media.	Analyze the computer's leading parts and BUS path.	Analysis (C4)
	Analyze the main constituent components of computer architecture and interconnect paths.	Analysis (C4)
	Analyze the central computer architecture and interconnect features.	Analysis (C4)
	Make a definition, imagine data, control, and address bus interconnectivity lines.	Evaluation (C5)
	Design an experiment comparing data, address, and control bus interconnections.	Creation (C6)
Students conclude experimental data analysis of the computer bus system's primary structure and interconnection path.	Make a definition of bus interconnect data transfer.	Evaluation (C5)
	Analyze the data communications utilized in connection pathways.	Analysis (C4)
	Development of operational principles for bus interconnection lines	Creation (C6)

Data Collection

Each learning model (Project STEAM and Direct STEAM) was applied to students taking computer architecture courses for ten weeks. Researchers determined ten weeks to ensure optimal treatment and reduce internal validity gaps throughout the study. See Table 5.

Treatment is carried out in each class by integrating the STEAM approach. Classes that study with the Project STEAM model adjust their learning steps, starting from trigger questions to evaluating learning experiences. Likewise, in classes with the Direct STEAM model, learning activities include an introduction and a presentation to repetition. The learning syntax for the project STEAM and direct STEAM models is shown in Table 6.

Data Analysis

Internal consistency of test items is a measure that shows an instrument's validity level, including testing the validity of the content through expert tests, internal consistency, and the reliability of the test. The overall test results are sufficient for the instrument to be used in research. The information provided by this research was analyzed using descriptive approaches and Multivariate Analysis of Covariance (MANCOVA). MANCOVA data analysis decreases bias during experiments by separating variations arising from variables from error variances. This produces a more convincing difference test between groups of independent variables. So, the goal of covariates is to clean away biassed factors caused by the inequality of treatment groups. Preliminary tests were performed before evaluating the study

Table 5: Research Time Plan

	Week	
1	*2-9*	*10*
Socialization of the application of the Project STEAM & Direct STEAM learning model and (Pretest)	Treatment of Project STEAM models in experimental classes and Direct STEAM models in control classes	Postest to the whole class group

Table 6: Project STEAM and Direct STEAM Learning Syntax

No	*Syntax Project-based Learning*	*Syntax Direct Learning STEAM*
1	Define topics related to computer architecture material and ask stimulating questions. (Science and Technology)	Introduction to and Presentation of Computer Architecture Learning Material (Science and Technology)
2	Create a project design to solve problems related to bus inter-connection lines in computer architecture. (Technology and Engineering)	Demonstration and Explanation (Technology and Engineering)
3	Prepare a project work schedule along with project time and progress. (Arts and Mathematics)	Discussion and Practical Exercises (Science, Technology, and Engineering)
4	Monitor the progress of computer architecture projects carried out by each group of students. (Engineering and Art)	Correction and Repetition of Materials (Engineering and Art)
5	The results of the product assessment of project-based learning activities are presented in front of the class. (Science, Technology, Engineering, Art and Mathematics)	Evaluation, Feedback, and Adjustments (Science, Technology, Engineering, Art, and Mathematics)
6	Evaluation of project-based learning experiences and structuring learning experiences. (Science, Technology, Engineering, Arts and Mathematics)	Repetition (Science, Technology, Engineering, Art, and Mathematics)

hypothesis, such as data normality and homogeneity tests, linearity and meaningfulness tests of regression direction, and multicollinearity.

Findings

The statistical analysis presents the data on creative thinking skills and student learning achievement before and after the test in Table 7. This data is organised based on academic self-efficacy, utilising standard deviation and mean to summarise the distribution and average value (Tab;le 7).

Based on what is shown in Figure 1. The data showed an average difference between students' creative thinking skills and achievement before and after treatment. In creative thinking skills, the students who studied project-STEAM+HASE increased from the poor category to very good, and those who learned with the project-STEAM+LASE increased to good. While the control group that studied with Direct STEAM+HASE grew from less good to sound, the Direct-STEAM+LASE control group increased to good. The average difference was also seen in student achievement,

Table 7: Recapitulation Standard Deviation (SD) and Mean (M) of creative thinking Skills (CT) and Student Achievement (SA) of Students who Study with Project-STEAM and Direct-STEAM

Creative Thinking Skills				
	Project STEAM		*Direct STEAM*	
Group	*Pre-test*	*Post-test*	*Pre-test*	*Post-test*
HASE	M = 25.88	M=31.76	M=18.44	M=26.16
	SD =5.72	SD=2.94	SD=5.66	SD=3.95
LASE	M=22.08	M = 26.80	M=21.16	M = 20.24
	SD=5.83	SD = 3.92	SD = 5.22	SD = 3.00
Student Achievement				
Group	Project STEAM		Direct STEAM	
	Pre-test	Posttest	Pre-test	Posttest
HASE	M=47.20	M=72.80	M=31.46	M=57.60
	SD=10.90	SD=17,31	SD=12.69	SD=15.2
LASE	M=32.50	M=54.93	M=30.40	M=38.67
	SD=11.60	SD=11.59	SD=18.76	SD=14.5

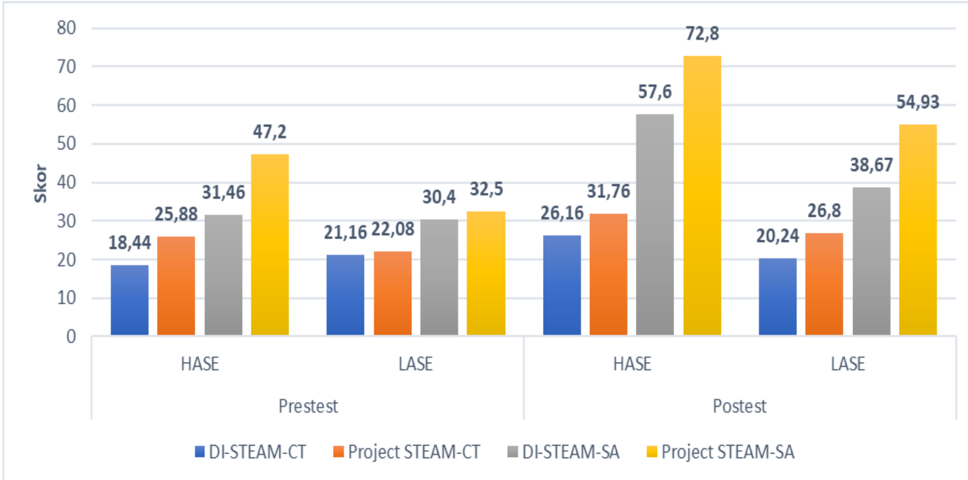

Figure 1: Data on Four Groups of Pretest and Post-test Creative Thinking Skills and Student Achievement

Table 8 MANCOVA Analysis Test Summary

Source	*Dependent Variable*	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Learning Model	CT	669.124	1	669.124	53.065	0.000
	SA	5266.231	1	5266.231	23.125	0.000
Academic Self-Efficacy	CT	590.499	1	590.499	46.830	0.000
	SA	6928.923	1	6928.923	30.426	0.000
Learning Model * Academic Self-Efficacy	CT	11.807	1	11.807	0.936	0.336
	SA	52.681	1	52.681	0.231	0.632

where the group studying with project STEAM+HASE increased from less good to very good, and the project-STEAM+LASE group grew to the excellent category. In the control group, students with Direct-STEAM+HASE increased from less good to sound, and changes also occurred in the Direct-STEAM+LASE, where low self-efficacy increased to good category (Figure 1).

Normality, homogeneity, linearity, and multicollinearity tests have been performed, and the results can be used to test hypotheses. According to the summary of the MANCOVA data analysis test in Table 8, the findings are as follows. The first influence of the learning model on students' creative thinking skills results in an *F* score of 53,065, and a significant score of $p = 0.000$ is less than 0.05. So, it rejects H0, and there is a significant difference in creative thinking skills between pupils who learn using the Project-STEAM and Direct-STEAM models. Creative thinking skills in the project-STEAM learning model were obtained (M = 29.32 SD = 4.49), which were higher than those of the direct learning STEAM learning model (M = 23.20 SD = 4.82).

Second, The *F* value for the learning model's effect on student achievement (SA) is *F*(23,125)., where the price (*F*tabel:0.05) = 2.70. The calculated *F* is greater than the table *F*(23.125>0.05) and the sig value. 0.000 < 0.05. According to these findings, student achievement differs significantly between students who learn using the Project-STEAM model and those who study with Direct-STEAM. Student achievement in the STEAM project model (M=63.59 SD=18.88) was higher than in the Direct-STEAM model (M=48.93 SD=15.35). Third, the effect of academic self-efficacy on creative thinking skills showed an *F* value = 46,830. In contrast, from the analysis results, the *F*table value with a significance of 0.05 = 2.70 obtained a calculated *F* value more significant than the *F*table (46,830>2.70) and sig value. 0.000 < 0.05. The analysis showed Ho was rejected. That is, there was a substantial difference in creative thinking skills between students with high and low academic self-efficacy. Students with high academic self-efficacy (M=29.00 SD=4.28) were higher than those with low academic self-efficacy (M=23.20 SD=4.61).

Fourth, the effect of academic self-efficacy on student achievement showed a price of *F*(30.426), more significant than *F* Table (2.70) and sig value. 0.000 < 0.05. The analysis showed a significant difference in student's achievement with high and low academic self-efficacy. Descriptive results showed that students with HASE (M= 65.20 SD=17.09) were higher than those with LASE (M=47.33 SD=17.79). Fifth, the *F* value on the influence of academic self-efficacy interactions (HASE vs LASE) and learning models (Project-STEAM vs Direct-STEAM) on creative thinking skills showed a score of *F*(0.936) and a score of *F*(0.231) on student achievement. Both F scores calculated from creative thinking skills and student achievement are smaller than *F* tables: 0.05. This analysis shows that H0 is accepted, meaning there is no interactive influence between learning models (Project STEAM vs Direct STEAM) and academic self-efficacy (HASE vs LASE) on students' creative thinking skills and achievement. The Project-STEAM and Direct-STEAM learning models can be used for students with high and low academic self-efficacy.

Discussion

This research successfully applies the Project-STEAM learning model to support students' creative thinking skills and achievement. Statistical analysis showed that the experimental class group was superior to the control class group. These results are based on research by López & Palacios (2024; Santyasa et al. (2020), who found significant improvement in learning outcomes through project-based learning activities. The project-STEAM learning model provides new experiences for students to explore learning materials through project activities integrated with STEAM components. Constructivist theory, where the centre of learning is students, gives students more space to explore their knowledge through actual activities and around their environment. The findings of this study are reinforced by Alfayez's research (2024), which explains that the STEAM approach provides a positive attitude and fosters motivation for the learning process. The findings of this study align with the research of Hawari & Noor (2020) and Randazzo et al. (2021), who found that increased learning activities that impact improved learning outcomes are supported by collaboration between friends through study groups. Activities that provide more opportunities to students and are carried out on a project-based basis have an impact on improving students' creative thinking skills and student achievement. An example of the final product produced by students learning with the Project-STEAM distribution model is shown in Figure 2.

According to Listiqowati et al. (2022), the phases in project-based learning can help students develop their thinking skills. Research Nurhasnah et al. (2023)namely STEAM-PjBL. The purpose of this research is to analyze implementation trends of STEAM-PjBL in science learning from elementary school level to university level. This research is a literature study by collecting 19 articles. This study adopted the review process by Sharif (2019 noted that the STEAM approach improves students' abilities to face the challenges of the 21st Century. In project-STEAM learning activities, all learning components become more specific, and students are challenged to complete them. Rati et al. (2023) stated that project activities provide

Figure 2: Example of the final product in a group of students studying with model project-STEAM

students with real experience related to learning materials and that collaborative support between friends in groups impacts the exchange of information directly applicable to problem-solving. Project STEAM learning is a syntax of determining project timelines and project monitoring that provides initiative support to students in learning, clear learning goals, and SMART (specific, measurable, achievable, relevant, and timeline). Research Sigit et al. (2022) stated that integrating the STEAM project fosters exploration to improve students' creative thinking. According to Pratiwi & Santyasa (2021) and Santyasa et al. (2019), project-based learning prepares students to locate reliable and reputable sources of information to enable project completion.

Previous research conducted by Suryaningsih & Ainun Nisa (2021) stated that collaboration and information exchange between friends in the group support the strengthening of new ideas. One of the answers of students who studied with the STEAM project explained the CA material analogous to the concept of online shopping, as shown in Figure 2. Through the analogy of online shopping, students can form different ideas and answers than usual, where the concept of a data bus is analogous to a package to be purchased, and the idea of an address bus is equivalent to a sender's and recipient's addresses. A control bus is analogous to a courier expedition that delivers goods from the sender to the buyer. The analogy formed from project activities can improve creative thinking skills through forms and activities that occur in everyday life. Research results Sigit et al. (2022) stated that learning that provides more space for students to do hands-on experience supports students in asking different questions based on findings.

In contrast, to learn activities using direct learning, in which lecturers are more natural, students' skills to explore different questions become less optimal. Suryaningsih & Ainun Nisa (2021) stated that the project learning outcomes media is a bridge of information that other students can directly see and understand. Atmojo et al. (2022) and Randazzo et al. (2021)this study aims to analyze the extent to which the empowerment of the creative entrepreneurship learning-based discovery skills (CEL-BaDiS Up stated that learning testing and evaluation activities provide experience for students to find shortcomings and what needs to be improved in the next meeting. The syntax of testing and evaluation on the project-STEAM model also allows all students to dare to appear in front of the class with explanations regarding the learning material that each student understands.

In addition to being influenced by external factors, students, learning processes, and outcomes are also influenced by internal factors. Academic self-efficacy is an internal factor affecting student achievement (Capron et al., 2021; Rati et al., 2023). HASE impacts students' enthusiasm in learning to ask questions, do assignments as a form of self-development challenges, provide arguments, dare to appear in front of the class and be able to express opinions. Conversely, students with LASE are more passive in class, willing to speak when appointed, rarely have the desire to ask questions, and are less fluent if speaking in front of the class, which leads to student achievement that could be more optimal. Research findings related to the influence of academic self-efficacy on creative thinking skills and student achievement are strengthened by the study results (Yada, Leskinen, Savolainen, & Schwab, 2022), revealing that the power of academic self-efficacy impacts students' success. According to (Safithri, Syaiful, & Huda, 2021)guru tetap mengembangkan kemampuan pemecahan masalah siswa. PBL dan PjBL dilaksanakan dengan aplikasi Zoom Cloud Meeting membuat siswa dapat mengkonstruksi ide penyelesaian masalah. Tujuan penelitian untuk melihat perbedaan kemampuan pemecahan masalah siswa yang diajarkan dengan PBL dan PjBL secara daring berdasarkan self efficacy, melihat interaksi antara pembelajaran PBL, PjBL, self efficacy terhadap kemampuan pemecahan masalah siswa. Desain penelitian menggunakan quasi experimental non-equivalent control group design, dengan populasi seluruh siswa kelas XI IPA SMA N 5 Kota Jambi, dengan teknik pengambilan sampel yaitu simple random sampling didapat 2 kelas eksperimen dan 1 kelas kontrol. Instrumen penelitian yaitu tes, angket, dan lembar observasi. Hasil penelitian diuji dengan ANOVA dua arah, menunjukan terdapat perbedaan kemampuan pemecahan masalah siswa yang memiliki self efficacy tinggi, sedang, rendah yang diajarkan dengan PBL dan PjBL, namun tidak terdapat iteraksi antara pembelajaran PBL dan PjBL dengan self efficacy siswa terhadap kemampuan pemecahan masalah. Hal ini dikarenakan, sesuatu yang telah dimiliki oleh setiap individu siswa sebelum diberikan perlakuan dan metode pembelajaran oleh guru tidak ada interaksi nya terhadap kemampuan pemecahan masalah matematika siswa, karena siswa sudah memiliki keyakinan (self efficacy, Explaining academic self-efficacy to students makes an essential contribution to problem-solving skills. Academic self-efficacy greatly influences student behaviour and self-confidence to succeed (Bandura, 1993). Academic self-efficacy is an individual's belief that they can do a specific action (Schunk, 1991). Based on the study's findings, lecturers in learning activities must provide positive motivation, life experiences that build student confidence, and stories that reinforce students. According to (Nauvalia, 2021), students' academic self-efficacy can be created through lecturers' approach to learning, appreciation of knowledge, and stories of experiences that reinforce students' confidence to succeed.

Based on this description, a generalization can be made that high and low academic self-efficacy significantly influence students' creative thinking skills and achievement.

The study's outcomes show that the impact of the learning treatment provided (Project-STEAM and Direct-STEAM) on creative thinking abilities and student achievement is independent of students' academic self-efficacy. In conclusion, the two learning models used are appropriate for students with high and low academic self-efficacy. According to Jamaludin & Sriyansyah (2023), revealing innovative learning models, Project-Based Learning can be used in various student learning conditions. In the Direct-STEAM learning model, the comparison of academic self-efficacy could be more meaningful because student learning activities are more passive and more dominant explanations from lecturers. Some factors affect students' academic self-efficacy, including the lack of interaction, communication, and peer collaboration during the learning process (Nauvalia, 2021; Saepuloh & Suryani, 2020; Setiyadi, 2023). Project-STEAM learning model is carried out by forming learning groups to interact through communication and information exchange. In the Direct STEAM model, lecturers set learning by providing structured material, giving examples, and asking questions so that negative factors that affect academic self-efficacy can also be handled. The STEAM approach also concentrates on each component to be more creative in relating what happens around the neighbourhood to the material studied. Similarly, other factors affecting academic self-efficacy can be accommodated by applying the project-STEAM and direct-STEAM learning models. Based on research findings, a generalization can be made that both learning models (Project-STEAM vs Direct-STEAM) accommodate students' high and low academic self-efficacy.

Conclusion

The research aims to determine the effectiveness of the project-STEAM learning model compared to Direct-STEAM. Intervention is given to each group according to the learning syntax. Based on the analysis, a significant difference exists between the creative thinking skills and student achievement of students who learn with the project-STEAM and Direct-STEAM models. The creative thinking skills and student achievement of students who learn with the project-STEAM model are superior to students who study with Direct-STEAM. There are differences in creative thinking skills and student achievement between students with high and low academic self-efficacy. Furthermore, there was no interactive effect of learning models (Project-STEAM vs Direct-STEAM) and academic self-efficacy (HASE vs LASE) on creative thinking skills and student achievement. The study findings stated that both learning models accommodated differences in students' educational self-efficacy.

Suggestion

Suggestions that can be drawn from the findings of this research indicate the importance of improving 21st-century skills, especially creative thinking skills, to optimize learning outcomes at the tertiary level. Therefore, it is recommended that lecturers begin to deepen their understanding and apply the project STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning model in learning activities. This model has proven effective in stimulating students' creativity and problem-solving while strengthening the skills needed in the technology era. By integrating project STEAM elements into the curriculum, it is hoped that students can better develop their creative thinking skills to face complex challenges in work and society. It is hoped that implementing this learning model can create an inspiring learning environment and support the comprehensive development of students in higher education.

Limitation

The research is limited by the fact that implementing the STEAM project learning model has been shown to necessitate a significant amount of time. Occasionally, project tasks cannot be fully accomplished within a single meeting, necessitating students to continue the project activities during the subsequent meeting. Furthermore, the assessment mostly centers around the progression of project activities and has not yet encompassed the evaluation of the result. These constraints indicate that further investigation could enhance comprehension of time effectiveness in executing the project-STEAM learning paradigm and broaden assessment to encompass a more extensive evaluation of students' end outputs.

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