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The impact of differentiated learning in team-based project on undergraduate students' design thinking mindset

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ABSTRACT

Rapid advancements in science and technology necessitate that universities prepare students to be adaptable, flexible, and globally competitive through the mastery of design thinking. This study aims to determine the impact of differentiated learning in team-based projects (TBPj) in improving students' design thinking mindsets. The research methodology employed was a quasi-experimental design, with a non-equivalent post-test control group. The research sample comprised Jambi University Biology Education students selected using a purposive sampling technique. Student design thinking mindset was assessed using a questionnaire consisting of 84 statements and analyzed using the Mann-Whitney U-test. The results indicated that the control class design thinking mindset score (Mdn = 321.00) was significantly lower than that of the experimental class (Mdn = 374; U = 115.500, $p < 0.001$, $r = 0.67$). Based on these findings, it can be concluded that the implementation of differentiated learning in team-based projects (TBPj) has a high impact on improving students' design thinking mindset.

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INTRODUCTION

The world is changing rapidly due to advances in science and technology. To succeed in the future, students must demonstrate adaptability and flexibility. They need to be prepared for a highly technological and globally competitive environment by developing skills that differ from those previously required. Universities must respond to this paradigm shift by fostering students' design thinking.

Design thinking encompasses the capacity to identify problems and opportunities, conceptualize innovative solutions, and develop them into prototypes (Carroll et al., 2010; Ladachart et al., 2022; Pressman, 2019). This process involves multiple cognitive functions, including situation analysis, problem definition, idea modeling, solution design, outcome prediction, critical evaluation of unexpected results, and design process management (Sung & Kelley, 2019). Students must acquire proficiency in design thinking to enhance their ability to adapt to and address novel challenges (Bueno Muñoz et al., 2023), formulate innovative and creative solutions to problems encountered by themselves and others (Quaiser & Pandey, 2023), and evolve into optimistic, empathetic, and proactive members of society capable of contributing to the resolution of complex global issues (Bender-Salazar, 2023).

In the Asia-Pacific region, including China, South Korea, and India, design thinking has been promoted in higher education through learning programs (Koh et al., 2015; Kurokawa, 2013; Razali et al., 2022). Specifically, the development of design thinking in educational programs is encouraged to bridge the gap between education and industry needs in the global era (Dundar, 2022). However, research on design thinking in Indonesia remains limited, particularly at the Universitas Jambi. Observations made on biology education students at Universitas Jambi indicate that their design-thinking mindset is still lacking. This deficiency is evident from the inaccuracy of fundamental questions posed by students, which indicates their limited ability to identify and analyze problems. Additionally, although students have demonstrated the ability to provide concrete solutions to the problems presented, they continue to struggle in visualizing and developing these solutions into prototypes. Prospective teachers also exhibit confusion related to various challenges in curriculum changes, which suggests that their critical thinking, problem-solving, and innovation skills are still underdeveloped.

The low level of design thinking among students is attributed to the learning process that has not yet provided opportunities for students to explore problems and solutions according to their preferences. Although most lecturers in the Biology Education program at Universitas Jambi have implemented project-based learning, the majority of learning and projects have been predetermined by lecturers and are the same for all groups, thus failing to accommodate students' interests and design thinking. Based on this, the implementation of differentiated learning in team-based projects (TBPj) is necessary to encourage the development of students' design thinking. In this learning design, lecturers provide authentic problem and give autonomy to student groups to select and determine the projects they will work on throughout the semester to address issues according to their interests, learning styles, and creativity.

Research trends related to differentiated learning in the last three years have predominantly consisted of descriptive qualitative research (Fitra, 2022; Fitriyah & Bisri, 2023; Wahyuningsari et al., 2022) and classroom action research aimed at improving students' cognitive learning outcomes (Ardi Saputra & Rizki Susilowati, 2023; Septyana et al., 2023; Suwartiningsih, 2021). Research on project-based learning in the 2020-2023 timeframe is primarily in the form of quasi-experimental research and applied in learning to enhance 21st-century skills such as critical thinking skills (Aristin & Purnomo, 2022; Jeniver et al., 2023), creative thinking (Jaenudin et al., 2020), collaboration (Alfaeni et al., 2022), and communication [22]. The implementation of team-based projects to improve students' design thinking mindset has not yet been studied. Research related to differentiated learning in team-based projects in the last five years (2019-2023) has not been conducted. Research related to design thinking (2019-2023) is still limited to literature review (Panke, 2019; Rusmann & Ejsing-Duun, 2022; Vikas T N et al., 2022) and analysis (Polat & Bayram, 2022; Prayogi et al., 2023). This underscores the necessity of quasi-experimental research on the effect of differentiated learning in team-based projects (TBPj) on student design thinking mindset.

Based on the description above, the objective of this study was to assess the improvement of the design-thinking mindset among students exposed to differentiated learning integrated team-based projects (TBPj). This investigation is necessary to provide educational practitioners with empirical evidence regarding the efficacy of differentiated learning in team-based projects (TBPj) for developing students' design thinking, which is important for achieving success in a future that is constantly changing due to advances in science and technology.

RESEARCH METHODS

Research Design

This study employed a quasi-experimental research design with a non-equivalent post-test control group (Subali, 2019), as illustrated in Table 1. The investigation was conducted within the Biology Education Program of Jambi University from May to October 2024. The independent variable in this research was differentiated learning in team-based projects (TBPj), while the dependent variable was design thinking mindset.

Table 1. The research design

Class	Treatment	Post-test
Control	T_1	X_1
Experiment	T_2	X_2

Description:
T1 = Direct learning with assignment method
T2 = Differentiated learning in TBP
X1 = Post-test in the control class
X2 = Post-test in experimental class

Population and Samples

The population of this study consists of third-semester biology education students at Universitas Jambi in the 2023/2024 academic year, totaling 111 students distributed across three classes. The sample selection was conducted using a purposive sampling technique, with the criteria being students enrolled in the biology learning model course and both classes having nearly the same capabilities based on their previous learning achievements. Using this method, the research sample consisted of 72 students distributed into two classes, one class as the experimental group and the other as the control group.

Instruments

The students' design-thinking mindset was assessed using a non-test instrument in the form of a questionnaire comprising 84 statements. The statements in the questionnaire were structured according to design thinking indicators: 1) tolerance for ambiguity and uncertainty, 2) embracing risk, 3) human-centeredness, 4) empathy, 5) mindfulness and awareness of the process, 6) holistic view/consider the problem as a whole, 7) problem reframing, 8) team working, 9) multi-/inter-cross-disciplinary collaborative teams, 10) open to different perspectives/diversity, 11) learning oriented, 12) experimentation or learn from mistake or failure, 13) experiential intelligence/bias toward action, 14) critical questioning, 15) abductive thinking, 16) envisioning new things, 17) creative confidence, 18) desire to make a difference, and 19) optimism to have an impact. This instrument was adapted from the research conducted by Dosi et al., (2018), which has been deemed valid and reliable based on exploratory factor analysis.

Procedures

The research procedure employed in this study comprised three primary phases: 1) selection of two classes as research samples utilizing a purposive sampling methodology, with the criterion that both classes must exhibit homogeneity and normality. 2) Administration of treatment in the form of direct learning model implementation with assignment methodology in the control class and differentiated learning implementation in team-based projects. In the control class, the instructor delivered instructional content using the lecture method and subsequently assigned students to produce videos demonstrating the steps involved in applying various learning models. In the experimental class, differentiated learning in team-based projects was implemented using the following syntax: a) initiating with the essential question, b) designing a plan and creating a schedule, c) monitoring and progressing the project, d) assessing the outcome, and e) evaluating the experience. Following this syntax, students were allowed to analyze problems related to the application of learning models and create products as solutions to these problems by their abilities, interests, and creativity. 3) Measurement of students' design thinking mindset in both the control and experimental classes post-treatment.

Data Analysis

The design thinking mindset scores are ordinal data derived from a rating scale; thus, the data were analyzed using non-parametric statistics (Hamilton, 2024). According to the research design, the non-parametric statistic used is the Mann-Whitney U-Test, conducted using SPSS software version 27. The magnitude of the effect of implementing differentiated learning in team-based projects on the design thinking mindset was determined based on the effect size value for the Mann-Whitney U-Test (r) as presented in Table 2 (Becker, 2000; Ellis, 2010).

Table 2. The criteria of Mann-Whitney U-Test effect size

No	R	Effect Size
1	<0.3	Low
2	0.3-0.5	Medium
3	>0.5	High

RESULTS

This study investigated the impact of implementing differentiated learning within a team-based project learning model to enhance the design thinking mindset of prospective biology teacher students. Data on students' design thinking following treatment in the control and experimental classes are shown in Figure 1.

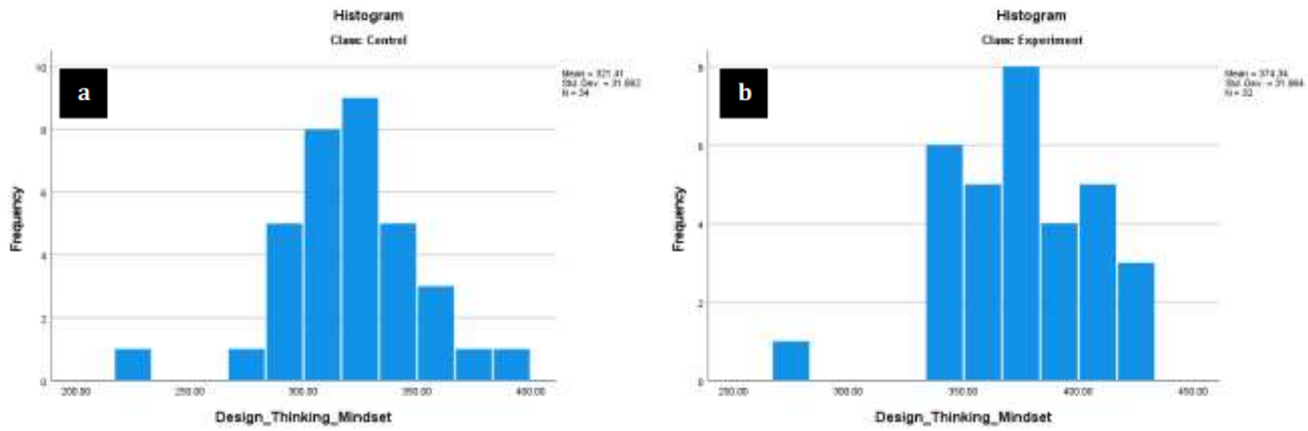

Figure 1. The distribution of student design-thinking mindset scores: a) control class and b) experiment class

The descriptive statistics presented in the graph indicate that the mean score of students' design thinking mindset in the control class was 321.41 (SD = 31.892, Mdn = 321.00), while in the experimental class it was 374.34 (SD = 31.964, Mdn = 374.00). This demonstrates a substantial difference between the students' design-thinking mindset rank in the control and experimental classes, with a mean difference of 52.93. The design-thinking mindset data are ordinal and derived from two distinct groups; therefore, the data were analyzed using non-parametric statistics, specifically the Mann-Whitney U test (Table 3).

Table 3. The results of the Mann-Whitney U test

	Design-Thinking Mindset
Mann Withney U	115.500
Wilxocon W	710.500
Z	-5.499
Asymp. Sig. (2-tailed)	<0.001

The results of the analysis utilizing the Mann-Whitney U test revealed that the design-thinking mindset score of the control class (Mdn = 321.00) was significantly lower than that of the experimental class (Mdn = 374), U = 115.500, $p < 0.001$. This finding suggests that the implementation of differentiated learning has a significant effect on students' design-thinking mindsets. The magnitude of this effect was determined based on the effect size value for the Mann–Whitney U test (r), as presented in Table 4.

Table 4. The category of improvement design-thinking mindset

Data	R	Effect Size
Design-Thinking Mindset	0.67	High

The results presented in Table 3 demonstrate a correlation coefficient of $r = 0.67$, indicating that the implementation of differentiated learning in the team-based project (TBPj) has a high impact on improving students' design-thinking mindset.

DISCUSSION

Learning in higher education pertains to an outcome-based education (OBE) curriculum designed to enhance graduates' adaptability to 21st-century changes. A design thinking mindset is one of the competencies that facilitate adaptability and flexibility in response to rapid change. This skill encompasses the ability to identify problems and opportunities, conceptualize innovative solutions, and develop them into prototypes that can enable students to respond effectively to 21st-century challenges, which are predominantly influenced by science and technology. In this context, this study investigated the impact of implementing differentiated learning within a team-based project learning model to enhance the design thinking mindset of prospective biology teacher students.

Differentiated learning is an educational approach that aims to adapt the learning process to the individual needs, abilities, interests, and learning styles of students. In this approach, educators develop diverse instructional strategies and methodologies to accommodate classroom heterogeneity. This can encompass variations in the content taught, the learning process, as well as the academic outputs produced by students (Eikeland & Ohna, 2022; Langelaan et al., 2024). The primary objective of differentiated learning is to ensure that every student, regardless of ability level or interest, can develop optimally and receive instruction tailored to their specific requirements. Consequently, this approach positions the student at the center of the learning process, with the educator serving as a flexible facilitator in supporting individual development. Meanwhile, team-based project learning is an inquiry-based pedagogical model in which students collaboratively construct knowledge through the completion of authentic projects for problem-solving or the achievement of specific learning objectives related to the curriculum (Guo et al., 2020). In this study, differentiated learning was implemented within the context of project-based learning, wherein lecturers presented lecture topics and directed students to analyze authentic problems related to these topics. Lecturers grant autonomy to student groups in selecting and determining projects aligned with their learning styles, interests, and creativity, which will be developed over one semester as a solution to the analyzed problems.

The results indicate that the implementation of differentiated learning in team-based projects has a significant effect on enhancing students' design thinking mindsets, which aligns with several previous studies examining comparable learning designs. Dalila et al., (2022) demonstrated that differentiated learning facilitates improvement in students' cognitive learning outcomes. The application of differentiated learning also enhances critical and creative thinking skills (Lestari et al., 2024). Moreover, additional studies have demonstrated that project-based learning can enhance problem-solving skills (Karan & Brown, 2022), critical thinking skills (Jeniver et al., 2023), creative thinking skills (Deria et al., 2023; Pramesti et al., 2022), and students' social attitudes (Berhitu et al., 2020). Additionally, project-based learning implemented in group settings has been shown to improve collaboration and communication skills (Crespí et al., 2022; Harjono et al., 2023; Sagala et al., 2019), where the improvement in the skills outcomes described represents several indicators of the design-thinking mindset.

Differentiated learning in Team-Based Project (TBPj) significantly contributes to the development of students' design thinking mindset, as its approach facilitates active engagement and profound reflection at each stage. The TBPj process begins with formulation of an essential question. Essential questions are primary inquiries formulated by students, which must be addressed and resolved through a project (Hamidah et al., 2020). The formulation of the essential question facilitates students' comprehension of the project focus, determines the project type, and guides the investigation process. Formulating essential questions stimulates intellectual curiosity and encourages students to analyze problems in depth. This directly enhances the ability to tolerate ambiguity and uncertainty, and elicits critical thinking. Students are encouraged to comprehensively consider various aspects of the problem and perceive challenges as opportunities for learning, which strengthens their creative thinking and receptiveness to novel ideas.

The second phase involved designing the project and timeline. Project design activities encompass the selection of project types based on essential questions and the determination of activities in the inquiry process (Hamidah et al., 2020). These project design activities facilitate students' development of critical thinking skills through project type selection, problem-solving, and the ability to plan activities in the inquiry process. This stage also encourages students to engage in risk-taking and collaborative behaviors. During this process, students learn to work in teams, share ideas, and appreciate the diverse perspectives of the team members when designing innovative solutions. Additionally, it fosters empathy, as students must comprehend the user's perspective and needs, which are crucial to design thinking.

The third phase involved project completion and monitoring. This stage constitutes the primary phase wherein students execute the project as designed, commencing from the investigation process and culminating in project completion (Hamidah et al., 2020). This stage facilitates the development of students' skills in data and information processing, problem-solving, independence, teamwork, and inter-group communication skills among project participants. The project completion process also fosters the development of creativity and abductive reasoning, whereby students must identify the most feasible and appropriate solutions when confronted with the challenges that arise during the project completion process.

The fourth phase involved the presentation of the project results. At this stage, the student groups presented their project outcomes, whereas the other group members posed questions regarding the presented results. Concurrently, the teacher conducted a formative assessment using a rubric to evaluate the project process and outcomes (Hamidah et al., 2020). The presentation stage of the project results provides a platform for students to share ideas, discuss findings, and receive feedback, which is crucial for design-thinking development. This process not only cultivates the ability to present work with confidence but also fosters optimism and self-assurance that their contributions can have a positive impact.

The final stage in project-based learning is evaluating the project, in which the instructor assesses the outcomes by providing feedback on the project results while the students reflect on the learning activities (Hamidah et al., 2020). The process of evaluating the learning experience after the project emphasizes the significance of reflection, which facilitates students' internalization of the experience and enhances their motivation to make changes in the future.

Based on the aforementioned description, differentiated learning in team-based projects demonstrates a comprehensive capacity to cultivate indicators of students' design-thinking mindsets. Through active engagement in the project, students can develop the ability to manage uncertainty, perceive challenges as learning opportunities, employ abductive reasoning to determine optimal solutions, undertake calculated risks, collaborate with diverse stakeholders, demonstrate empathy, appreciate varied perspectives, and apply critical and creative thinking in project completion.

CONCLUSION

This study investigated the impact of differentiated learning through team-based projects (TBPj) on students' design thinking mindsets. Conclusive evidence demonstrated that differentiated learning through TBPj had a high impact on the development of design thinking among undergraduate students [$U = 115.500$, $p < 0.001$; $r = 0.67$]. The implementation of differentiated learning through team-based projects cultivates students' ability to tolerate uncertainty, analyze problems as learning opportunities, employ abductive reasoning to select the most appropriate alternative solutions in problem-solving, demonstrate risk-taking propensity, value diverse perspectives in decision-making, engaging in team collaboration, and applying critical and creative thinking in project completion. The findings of this study corroborate that differentiated learning through team-based projects is an effective approach to enhancing design design-thinking mindset, equipping students with the requisite skills to address complex challenges in the future. In this study, an assessment of design thinking was conducted using a questionnaire. Further research is warranted to evaluate design thinking using essay tests to comprehensively examine the positive impact of differentiated learning through project-based learning on improving students' design thinking.

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