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How the Mobile App-Assisted Project-Based Learning Model Improves Students' Critical Thinking Ability

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Abstract:

A project-based learning (PjBL) model based on mobile apps provides the knowledge and skills required for a job. The ability of students to continue learning is necessary to solve new problems and challenges. This survey-approached quantitative study aims to reveal how the mobile app-assisted PjBL model affects critical thinking skills and student achievement in entrepreneurship courses. Data were collected using observations, tests, and questionnaires. The sample in this study consisted of 100 students majoring in economic education. Data analysis used SPSS 22 through paired samples and simple linear regression tests. The findings show that Sig (2-tailed) 0.000 < 0.05, which means that the mobile app-assisted PjBL learning method is effectively applied in entrepreneurship courses, and an N-gain score of 0.7738 or N-gain percentage of 77.38% is the high criteria. Student responses after implementing the mobile app-assisted PjBL learning model showed a score of 75.2%, with good criteria. After implementing the mobile app-assisted

Keywords:
Project-based learning,
Students,
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Critical thinking
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PjBL learning model, student responses indicated a 75.2% score with good criteria. Mobile app-assisted PjBL in entrepreneurship courses can be an alternative learning model for students to participate actively.

行動應用輔助的項目式學習模式如何提升學生的批判性思考能力

摘要：

基於行動應用程式的專案式學習模型提供工作所需的知識和技能。學生持續學習的能力是解決新問題和挑戰所必需的。這項採用調查方式的定量研究旨在揭示行動應用程式輔助的基於專案的學習模型如何影響批判性思考技能和學生在創業課程中的成績。透過觀察、測試和問卷調查收集數據。本研究的樣本由 100 名經濟教育專業的學生組成。資料分析使用 SPSS 22，以配對樣本和簡單線性迴歸檢定。研究結果表明，Sig（2-有尾的）0.000 < 0.05，這意味著行動應用輔助的基於專案的學習學習方法在創業課程中得到了有效的應用，並且 N-獲得得分為 0.7738 或 N-獲得百分比為 77.38%高標準。實施行動應用程式輔助的基於專案的學習學習模式後，學生的反應分數為 75.2%，符合良好標準。在實施行動應用程式輔助的基於專案的學習學習模式後，學生的反應顯示得分為 75.2%，符合良好標準。行動應用輔助的基於專案的學習創業課程可以成為學生積極參與的另一種學習模式。

关键词：基于项目的学习、学生、移动应用、批判性思维, 创业

1. Introduction

The rapid development of information technology in education has become both an opportunity and a challenge for entrepreneurship education in higher education. Learning media aims to create more communicative and meaningful learning opportunities for students. Along with increasingly advanced technological developments, educators can use many alternative media to help students learn; one technology that is currently popular with the public is mobile learning (Aripin, 2018). In the student-learning-centered learning approach, the lecturer acts only as a facilitator and motivator in the learning process. However, this ideal has not yet been optimally achieved because many lecturers apply conventional learning processes so that students are accustomed to listening to lectures delivered by lecturers. They will not be able to empower students' skills in critical thinking (Munawaroh et al., 2022).

One of the basic considerations for developing mobile-based teaching media is flexibility in accessing information anytime and anywhere (Nealbert et al., 2014). Android operating system used by most smartphones is open source, which allows the source code on Android to customize various application features (Hakim, 2015). According to its effectiveness in learning, Android mobile-based smartphone technology has the potential to provide new learning experiences because students are often directly involved in learning activities (Aripin, 2018). Another advantage of mobile-based teaching media is that it is cheaper than a personal computer (PC) or laptop. A cheaper smartphone has almost the same advantages as a PC because it can display multimedia elements in text, video, sound, animation, etc. Mobile technology can enhance learning by creating connected learning experiences. However, research on admissions and learning has demonstrated the importance of combining classroom and field teaching, a key feature of school learning. The mobile app-assisted project-based learning (PjBL) model is a learning concept that uses technology that makes the internet a database, and applications can be accessed with a computer or smartphone (Maritasari et al., 2022),

The first step is to improve entrepreneurial learning to instill an entrepreneurial spirit. Training can improve cognitive, affective, and psychomotor entrepreneurship. By selecting the appropriate methods and media, entrepreneurship learning will be attractive, inspiring, easy to understand, and can motivate students to learn entrepreneurship. Lecturers play an important role in providing various competencies to students; therefore, they need expertise in learning innovation, good counseling skills, and development. Students must also be able to follow the latest developments in educational curriculum development, integrate technology during the learning process, and internalize positive characteristics (Fuad et al., 2017).

Previous research has succeeded in measuring the effects of PjBL, namely, learning outcomes and motivation, problem-solving skills, creative thinking processes, leadership abilities, and communication skills. It increases students' motivation and facilitates mass-solving skills (Chiang & Lee, 2016), creative

thinking, and positive behavior (Mihardi et al., 2013). Implementing PjBL increases cognitive levels, self-efficacy, teamwork, and communication skills (Fini et al., 2018). Research results show that digital PjBL is effective for students' computational abilities in solving middle school mathematics problems (Indah et al., 2021), while other research shows differences in metacognitive skills before and after PjBL (Misa & Mariani, 2021). In addition, the low critical thinking skills of students are shown by the lack of student initiative in asking and answering when faced with various problems that require essential processes of thinking and problem-solving in the entrepreneurship course. In addition, problem-solving activities help students build new knowledge and facilitate science learning (Deb et al., 2015). To face the challenges of Industry 4.0, lecturers should prepare students to become researchers, solve problems, and think critically and creatively (Sholihah & Lenggono, 2020).

This research is about the effectiveness of a PjBL model based on mobile apps on students' critical thinking abilities. It needs to improve students' capabilities and create more meaningful and high-quality learning for economics education programs in entrepreneurship courses. This study aims to explain the effectiveness of PjBL based on mobile apps in improving students' critical thinking skills in entrepreneurship courses and student responses regarding the application of learning using the mobile app-assisted PjBL model in the entrepreneurship course.

2. Literature Review

2.1. Project Based Learning

PjBL is defined as a separate and specially organized activity of students, limited in time, aimed at solving a specific problem, which should result in a designed final product of the activity. The dynamic experience of introducing PjBL has made it possible to identify the differences between classical and modern models of project-based practice. The main goal of PjBL is to eliminate the gap between educational activities at universities and actual needs (Veselov, 2019). The PjBL model based on mobile apps is a long-term learning process that involves creating and displaying related products for solutions to real-life problems for students (Misa & Mariani, 2021). PjBL focuses on solving everyday problems through hands-on practice (Stozhko et al., 2015). PjBL requires students to possess professional technical abilities. Specific goals to be achieved include written and verbal communication skills, managerial abilities, entrepreneurship, lifelong learning, professional accountability, personal marketing, and inclusiveness (Eskrootchi & Oskrochi, 2010). The application of the PjBL learning paradigm can increase students' skill competency (Jalinus, 2017).

This PjBL model is interesting. It is supported by a project brief, in which students perform a series of tasks leading to the production of a final product, which can be a design, device, model, or computer simulation (Guo et al., 2020). PjBL has advantages over traditional learning, as shown by the results of a questionnaire in which almost all students expressed their belief that PjBL is interesting (Guo et al., 2020). Student responses to PjBL can increase student activities and abilities in industrial sanitation courses (Suseno et al., 2022).

PjBL is a learning method that exposes students to unfamiliar or complex problems with the stages of problem orientation, setting learning goals, carrying out a series of scientific investigations, collaborating, utilizing learning technology, and creating a product (Wijnia et al., 2024). This method involves students solving problems that exist in real life and producing final products that are relevant to the existing case. In other words, students are encouraged to have authentic experiences (Gülbahar & Tinmaz, 2006). In this case, students can develop their abilities in addition to having a deep understanding of a problem through a series of stages when searching for project solutions (Lillo, 2023). PjBL is one method that encourages effective learning. First, students are encouraged to actively build ideas and knowledge from a series of meaningful processes, namely, combining initial knowledge and exploring information from various sources about a problem. Working with people from different backgrounds can produce innovative ideas (Barak & Yuan, 2021; Splichal et al., 2018). Second, this learning method allows students to conduct investigations to solve problems and capture the relationships between various ideas (Gomez & Rodriguez, 2022). Third, collaboration between students, lecturers, and parties outside campus can enrich information, connect various views, and deepen understanding (Schneider et al., 2005; Krajcik, 2015; (Shin et al., 2021). Fourth, communication makes it easier for students to obtain reinforcement while completing projects. The different insights of practitioners and students complement each other in creating new ideas for a project (Usher & Barak, 2020).

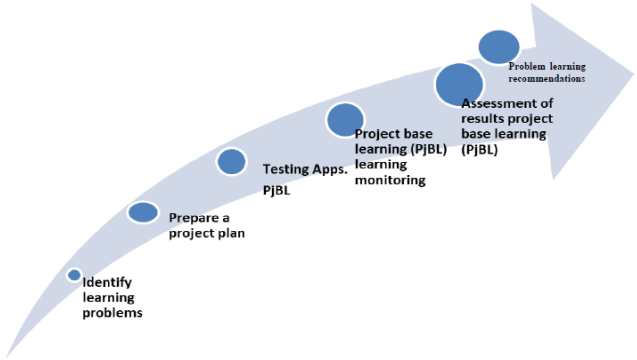

Figure 1. The project-based learning model (Developed by the authors)

2.2. Mobile Apps

Smartphones have now become a part of our daily lives, both personally and socially, and at work, regardless of gender, ethnicity, race, or social status (Lau et al., 2020). Each new version of a mobile device always brings innovative features that make it more convenient and affordable and new applications are constantly available that make life easier (Newhook et al., 2015). The use of cellular devices and smartphones has become one of the changes in 'modern culture, including in the field of education. The use of mobile devices has changed traditional classroom learning to become more interactive and interesting (Zydney & Warner, 2016).

Technological innovation, in the form of smartphone use, seeks to design learning through a pPjBL approach based on mobile apps. Mobile learning is distance learning that focuses on cross-context learning and learning using mobile devices/smartphones that can be done anytime and anywhere (Mohtar et al., 2023). Mobile Apps are learning tools that enable students to learn, collaborate, and share opinions with the help of the Internet and technological developments (Al-Emran et al., 2016). The use of mobile apps can increase learning motivation for students based on research (Booton et al., 2023).

2.3. Critical Thinking Skills

Critical thinking is an important ability that must be developed in a student and is the main goal in education (Nehru et al., 2024). A student must be able to solve every problem that exists in society with the knowledge they have learned, and one of the provisions is critical thinking skills. Critical thinking skills are a person's skills in analyzing, solving problems, and evaluating their own opinions that require discipline and deep and logical thinking (Rahmawati & Wulan, 2022).

The characteristics of the ability to think critically are first being able to involve oneself in carrying out tasks even though the solution is not immediately apparent; second, making efforts to maximize (manage) one's abilities and knowledge; third, creating, using, and improving evaluation standards that one makes himself (assessing personal performance); fourth, producing ways to new in seeing the environment and the constraints that apply in society (Fauziah, 2015), Based on research (Yustina, 2020), (Anazifa & Djukri, 2017) (Issa & Khataibeh, 2021)that learning through the PjBL method improves students' critical thinking skills.

3. Methods

3.1. Research Design

The research method used was quasi-experimental with a group pretest–posttest design (Haegele & Hodge, 2015). Students took a pretest to determine critical thinking ability data before applying the PjBL model based on mobile apps. The treatment of the PjBL model based on mobile apps was carried out after obtaining different results four times, followed by a posttest to obtain data on critical thinking abilities from the entrepreneurship course (Table 1).

Table 1. One group pretest– posttest research design; Source: Haegele & Hodge (2015)

Pretest	Treatment	Posttest
O1	X	O2

3.2. Population and Sample

The economic education study program involved entrepreneurship courses for a total of 50 students. This study consisted of one independent variable and one dependent variable. The independent variable was the PjBL learning model based on mobile apps and the dependent variable was students' critical thinking abilities in the entrepreneurship course.

3.3. Data Collection Techniques

This research used data collection techniques, namely observation, interviews, documentation, and questionnaires. Observation guidelines are used to determine the suitability of PjBL design and implementation of mobile apps. The test was used to determine the level of students' critical thinking abilities, while the questionnaire was used to determine students' responses to the application of the PjBL model based on mobile apps.

3.4. Data Analysis

Analysis of the research data was performed using the paired sample test with the SPSS 22 software application.

4. Results

Based on Table 2, using the mobile app-assisted PjBL method, the pretest results with the number of cases N = 50 had a mean of 62.02, standard deviation (SD) = 2.567, and a mean standard error of 0.363. Posttest with several cases N = 50 respondents; mean = 91.30, standard deviation = 2.573, and standard error of the mean = 0.364.

Table 2. Paired samples descriptive statistics (Developed by the authors)

	Test	Mean	N	SD	Std. error mean
Pair 1	Pretest	62.02	150	2.567	.363
	Posttest	91.30	150	2.573	.364

Table 3. Paired samples test (Developed by the authors)

		Paired differences					t	df	Sig. (2-tailed)
		Mean	SD	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Pretest-posttest	-29.280	1.386	.196	-29.674	-28.886	-149.419	49	.000

Based on Table 3, the paired samples test above shows that Sig (2-tailed) 0.000 < 0.05, indicating that there is a difference between the pretest, namely before there is a learning treatment using the mobile-based PjBL model, and the posttest, namely after learning with the mobile app-assisted PjBL method. This means that the mobile app-assisted PjBL learning model can be effectively applied to entrepreneurship courses. Next, the statistical descriptive results of the N gain value of implementing the mobile app-assisted PjBL learning method on students' critical thinking abilitiesare presented.

Table 4. Descriptive statistics (Developed by the authors)

	N	Min	Max	Mean	SD
N-gain score	100	.66	.89	.7738	.05585
NgainPercent	100	65.85	88.57	77.3790	5.58535
Valid N (listwise)	100				

Table 4 shows that the minimum N-gain score value was 0.66 and NgainPersen was 65.85%, while the maximum N-gain score was 0.89 and NgainPersen was 88.57%. The average N-gain score value is 0.7738 and NgainPersen is 77.37%. The standard deviation (SD) of the N-gain score value is 0.05585 and NgainPersen is 5.58%.

Table 5. Interpretation of gain values (Developed by the authors)

Value of g	Characteristics
$-1 \leq g \leq 0.0$	Decrease
$g = 0.0$	Stable
$0.0 \leq g \leq 0.30$	Low
$0.30 \leq g \leq 0.70$	Average
$0.70 \leq g \leq 1.00$	High

The increase in students' critical thinking skills in entrepreneurship courses after implementing the mobile app-assisted PjBL learning model is shown through the average N-gain score value of 0.7738 or 77.38 percent. Based on the gain value interpretation criteria, the average N-gain score value of 0.7738 is greater than 0.70, so it is declared to be high (Table 5). This shows that the PjBL learning model based on mobile apps is very effective when applied to economics education study program students for entrepreneurship courses.

5. Discussion

Problems related to learning in the 21st century show that lecturers need to create materials to develop students' critical thinking abilities in order to achieve a high understanding of knowledge. This skill allows students to think critically, exhibit reflective behavior, and aims to train students to become independent learners (de los Clemente, 2003).

The research results show that the mobile app-assisted PjBL learning model is effectively applied to students in entrepreneurship courses with an average score of 77.39 percent. This is in line with previous research (Wahida et al., 2015), which stated that students' posttest scores increased after implementing the PjBL model. The study by Inayah et al. (2021) shows that the PjBL model is better than conventional learning for the learning outcomes obtained by students. Students play an active role and exchange ideas, learn to express opinions, and seek information from their group partners. The PjBL model provides new experiences and knowledge for students because they indirectly learn to become scientists, taking scientific action in implementing a project, starting from formulating problems, determining procedures, determining the tools and materials needed, conducting investigations, designing and creating products, presenting or communicating products as a result of the investigation process, and conducting group discussions. This course activity provides a stimulus for students to increase their positive attitudes toward science learning. The dominance of students in learning using the PjBL model will develop several other attitudes related to science, namely enjoying science lessons, not making science learning a scary subject, and training students to be critical of existing problems (Pratama & Prastyaningrum, 2016).

For the critical thinking ability variable, the results of the N gain score show a value of 0.7738 > 0.7, which has a significant influence on the effectiveness of the PjBL learning model based on mobile apps, and there is an increase in students' critical thinking abilities. This shows that critical thinking can be seen as students' ability to compare two or more pieces of information. If there are differences and similarities, they will ask questions or comments with the aim of getting an explanation (Younis et al., 2021). Critical thinking skills reflect the ability to make rational judgments using concrete evidence (Munawaroh, 2020). This means that the PjBL model, based on mobile apps, teaches the main content and academic standards of scientific disciplines while encouraging students to think critically, solve problems, and collaborate (Edmunds et al., 2017). Increasing students' critical thinking abilities because the mobile app-assisted PjBL learning model requires them to collect and integrate new knowledge based on their experience in actual activities (Idkhan, 2017). PjBL has a significant and

direct effect on improving students' abilities and soft skills. In PjBL, based on students' experiences in actual activities, problems are the first step toward obtaining and integrating new information. This is supported by (Trisdiono et al., 2019) who stated that PjBL can improve students' creative thinking abilities. Students' critical thinking abilities can increase to a high level after the mobile app-assisted PjBL learning process (Trisdiono et al., 2019). In line with research (Sasson et al., 2018), which states that students in innovative learning environments (PjBL) show significant advantages over their peers in traditional classes in critical thinking.

The mobile app-assisted PjBL learning model is effective because it emphasizes contextual learning and shows advantages in developing communication and collaboration skills, as well as student creativity, so that projects produce entrepreneurial products in line with research (Puji & Asiyah, 2022). The results of this research show that, in the response questionnaire, 75% of students said it was good that PjBL learning based on mobile apps increased their sense of responsibility. In line with research conducted by (Musa et al., 2012) shows that PjBL learning based on mobile apps contributes to the development of soft skills which include responsibility, self-confidence, social and communication skills, flexibility, team spirit, good work attitudes, self-motivation, and self-management. PjBL has succeeded in exposing students to various skills, such as teamwork, conflict management, decision-making, and communication skills (Musa et al., 2012). Students' increased sense of responsibility as they become involved or participate in project planning gives them the feeling that their skills are improving, including team communication, independent thinking, deep learning, the ability to express themselves in a multidimensional way, and dealing with real-world problems. Research on the use of Android-based mobile learning shows effective and significant results. Several studies (Bustomi, 2010; Setyadi, 2017; Hakim, 2015) show that the use of Android-based mobile learning can improve students' understanding of biology, mathematics, and electronics. Research conducted by (El-Mouelhy et al., 2013) also concluded that the use of Android tablets in learning was able to increase students' understanding of the material.

Student responses to the application of the mobile app-assisted PjBL method were very beneficial for students in increasing their understanding of entrepreneurship material (75%). In addition, PjBL can increase students' interest in the materials provided (Aranzabal et al., 2022). This is supported by research conducted by Parrado-Martínez and Sánchez-Andújar (2020), who found that more than 96% of students recommended PjBL implementation. The advantages emphasized by students are the possibility of learning in a more practical, efficient, and motivating way; greater independence and autonomy in learning; the application of a constructive point of view in the learning process; and the possibility of knowing how theoretical concepts are applied to real problems. According to previous studies that have been conducted, students are taught to develop their thinking to build new knowledge about existing knowledge within the scope of the surrounding environment, enabling them to better understand what they are doing (Yance et al., 2013). Research results (Surahman et al., 2019) suggest that students are motivated to engage in project planning, collaborative problem-solving, and higher-order thinking skills in PjBL which requires critical thinking skills. Students who are actively involved in learning, from planning to evaluating, the project results, are more motivated to complete assignments and gain a better understanding of entrepreneurship materials.

The research results reveal that through mobile app-assisted PjBL learning models, it is easier for students to find solutions by organizing problems, namely, by sorting a problem, grouping the problems in detail, and combining one problem with another so that students can think critically. Solve problems in an organized manner and continue by preparing various necessary facts. Next, students carry out an analysis of existing problems and facts to find an outline for constructing an argument. However, what can be seen from the initial problems is that students are sometimes confused about understanding the problems posed. Therefore, the problems presented should not be expressed as questions, but rather entrepreneurial problems that occur in real life. The PjBL Learning Model based on mobile apps can improve students' learning outcomes, retention, interpersonal skills, and thinking skills. Therefore, this learning model can be used as an alternative to improve students' critical thinking skills.

The proposed learning model is interesting. PjBL is supported by a project brief in which students undertake a series of tasks leading to the production of a final product, which can be a design, device, model, or computer simulation. PjBL has advantages over traditional learning, as shown by the results of a questionnaire in which almost all students expressed their belief that PjBL is interesting (Guo et al., 2020). Student responses to PjBL can increase student activities and abilities in industrial sanitation courses (Suseno et al., 2022). Through PjBL, students acquire professional technical abilities. Specific targets include written communication skills, verbal communication, management skills, entrepreneurship, lifelong learning, professional responsibility, personal marketing, and inclusiveness (Eskrootchi & Oskrochi, 2010). Implementation of the PjBL learning model can increase students' skill competency (Jalinus, 2017) through planning process stages (Chang & Lee, 2010).

6. Conclusion

The probject-based learning (PjBL) model based on mobile apps is effectively applied to increase student's participation and critical thinking in entrepreneurship courses.

Author Contributions

Conceptualization, M.; methodology, M.; software, N.S.S.; validation, K.A.L.; formal analysis, L.S.; investigation, N.S.S., L.S. and K.A.L.; resources, N.S.S., L.S. and K.A.L.; data curation, L.S.; writing—original draft preparation, all authors contributed equally; writing—review and editing, M. and N.S.S.; visualization, L.S.; supervision, M.; project administration, M.; funding acquisition, M. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors on request.

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Conflicts of Interest

The authors declare no conflicts of interest.

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