Ed Process Int J

www.edupij.com

ISSN 2147-0901 (Print), 2564-8020 (Online)

EDUCATIONAL PROCESS
INTERNATIONAL JOURNAL

Research Article

Cite this article: Adnan, M. Z. Z., Majid, M. Z. A., Mafarja, N., Mohamad, M., Karim, A. A., & Wakimin, N. F. (2026). The Impacts Of M-Learning Tools on Students' Performance and Self-Directed Learning Capabilities in Economics Subjects. *Educational Process: International Journal, 22*, e2026040. https://doi.org/10.22521/edupij.2026.22.40

Received September 6, 2025
Accepted December 1, 2025

Keywords: M-learning, economics subject, student performance, self-directed learning, gamification, quality of education

Author for correspondence:
Mohamad Zuber Abd Majid
mzuber@ukm.edu.my
University Kebangsaan Malaysia

The Impacts of M-Learning Tools on Students' Performance and Self-Directed Learning Capabilities in Economics Subjects

Mohd Zaim Zainal Adnan, Mohamad Zuber Abd Majid, Nofouz Mafarja, Maslawati Mohamad, Aidah Abdul Karim, Nur Fadzlunnisaa' Wakimin

Abstract

Background/Purpose: This article examines the impact of M-learning tools in economics courses, focusing on students' academic performance, self-directed learning, and ability to manage their studies outside traditional classrooms. The underpinning theories are the Technology Framework Model (TAM) and the self-directed learning theory. Implementing these two theories is also aligned with 21st-century teaching and learning approaches.

Materials/Methods: The study used a quasi-experimental research design to identify the impacts of M-learning tools on students' academic performance and self-directed learning. There were 28 participants in both treatment and control groups. The research instruments were a set of questionnaires, a pretest, and post-tests. The data were analyzed using a paired t-test.

Results: The findings indicate that the M-learning tool for the economics subject has positive impacts on students' academic performance and self-directed learning capabilities. The integration of M-learning tools in economics courses significantly enhances students' academic performance and self-directed learning. The findings of this study provide insights for economics teachers on integrating M-learning tools into their classrooms.

Conclusion: This study offers a valuable contribution by highlighting the impact of M-learning on academic performance and the fostering of self-directed learning capabilities. The study's findings also illustrate the potential of M-learning tools to promote a flexible learning environment and self-directed learning capabilities. This study's findings also provide valuable insights for educators on integrating M-learning tools in their own classroom settings.

1. Introduction

The rapid advancement of digital technology has significantly transformed educational practices, leading to a shift from traditional learning to mobile learning (M-learning). M-learning refers to the use of mobile devices such as smartphones and tablets in teaching and learning. This shift has been particularly evident in higher education, where institutions have increasingly integrated M-learning tools to enhance the learning experience. For instance, a study conducted by Rangel-de Lázaro et al. (2023) highlighted the evolution of M-learning from supplementary material to a flexible and strategic resource in higher education. Similarly, a study by Bano et al. (2018) emphasized the multifaceted nature of M-learning tools, noting their potential to address various educational needs. These current studies underscore the educator's increasing reliance on M-learning tools in educational settings, and most of their findings have shown that M-learning tools are able to improve their students' engagement and academic performance.

Economics subjects or education play a pivotal role in equipping students with the analytical tools necessary to learn and comprehend complex financial landscapes. A solid foundation in economics helps improve individuals' decision-making, enabling them to make better-informed choices in both personal finance and broader economic contexts (Valero & Van Reenen, 2019). For instance, understanding economic principles is crucial for effective financial planning and resource allocation. Moreover, economics education fosters critical thinking and problem-solving skills, which are essential for addressing real-world challenges. Many studies indicate that individuals with higher levels of economic literacy are better prepared to participate in economic activities and contribute to societal well-being (Lusardi, 2019). Therefore, a more comprehensive economics education is vital for developing well- informed and knowledgeable citizens.

Despite the benefits, integrating M-learning tools presents many challenges. Mehdipour and Zerehkafi (2013) identified several barriers to the effective integration of M-learning tools, including technological issues such as device compatibility and connectivity. The issues on pedagogical concerns refer to the need for curriculum adaptations to accommodate mobile learning approaches. Additionally, the rapid pace of technological advancement could lead to disparities in access to and use of technology between developed and developing countries or regions. These challenges indicate that infrastructure development, professional development for educators, and curriculum redesign require attention from authorities and policymakers.

In Malaysia, there are many challenges to integrating M-learning tools in education. A study by Ishak et al. (2022) highlights that while educators recognize the benefits of technology for enhancing teaching and learning, they also face significant challenges in implementing it. These challenges include inadequate digital infrastructure, limited digital literacy among educators and students, and a lack of comprehensive training programs on the subject. Furthermore, this study emphasizes that teachers' readiness, beliefs, and perceptions regarding the integration of technology in their own classes are also contributing factors that affect the success of M-learning tool integration in Malaysian classrooms.

Addressing the above-mentioned challenges is imperative to yield the benefits of M-learning tools. In Malaysia, various initiatives are undertaken by the government and school authorities to enhance digital infrastructure and provide relevant training for educators to improve their digital literacy. Similarly, there is a concerted effort to develop policies and frameworks that support the integration of M-learning, ensuring equitable access and quality education for all learners globally. By tackling these issues, M-learning can become a powerful tool in transforming education, making learning more accessible, engaging, and effective for students locally and globally.

Many studies indicate that mobile learning (M-learning) tools can significantly enhance students' academic performance by providing interactive and personalized learning experiences. For instance, a study by Al-Emran et al. (2016) found that M-learning applications promote student engagement and motivation, leading to improved academic outcomes. Similarly, Crompton and Burke (2018) reported that the flexibility and accessibility of M-learning tools allow students to learn at their own pace, resulting in better understanding and retention of complex concepts. The integration of M-learning tools in economics courses has been shown to facilitate understanding of complex economic theories through interactive simulations and real-time data analysis (Lazarinis & Kanellopoulos, 2021). Furthermore, Sung et al. (2016) stated that the use of mobile devices in learning environments positively affects students' academic achievements across various disciplines. These findings suggest that incorporating M-learning tools in educational settings can be a valuable approach to enhance students' performance (Weichhart et al., 2018).

Self-directed learning (SDL) skills are important, particularly in higher education. Students with high self-directed learning capabilities take initiative and are responsible for their learning. Students could also navigate their educational journals more effectively with the assistance of M-learning tools. Law & Niu's (2019) research indicates that students with high levels of SDL are better equipped to engage with M-learning tools, leading to enhanced academic performance and deeper cognitive engagement. Moreover, the integration of SDL in M-learning environments has been shown to promote motivation and self-efficacy, as students actively participate in setting their own learning goals and monitoring their own progress (Jeno et al., 2019). Therefore, cultivating SDL skills is essential to maximizing the benefits of M-learning in economics education, as it encourages students to become proactive learners capable of comprehending complex economic concepts.

While M-learning tools offer numerous advantages, it also presents challenges and limitations that could impede their effectiveness, particularly in economics education. Technical difficulties, such as unreliable internet connectivity and device compatibility issues, can disrupt the learning process and hinder students' access to educational materials (Garzón et al., 2024). Additionally, the lack of digital literacy among students and educators may limit the optimal utilization of M-learning tools, leading to suboptimal learning outcomes (Garzón et al., 2024). Concerns about data privacy and security also pose significant barriers, as the use of mobile devices often entails handling sensitive personal information (Garzón et al., 2024). Furthermore, the potential for increased screen time raises health concerns, including eye strain and reduced physical activity, which can adversely affect students' physical and mental health (Garzón et al., 2024). Addressing these challenges is crucial to fully harnessing the potential of M-learning to enhance students' performance and promote self-directed learning in economics education.

The Technology Acceptance Model (TAM), introduced by Davis (1989), has been useful in understanding how users accept and use technology. TAM has been widely used to assess the adoption of various learning technologies, including mobile learning (M-learning) tools, particularly in educational contexts. For instance, Al-Rahmi et al. (2022) identified that perceived mobile value, academic relevance, and self-management of M-learning are primary drivers of students' acceptance of M-learning tools. Similarly, Al-Okaily et al. (2020) applied TAM to evaluate the university students' acceptance of e-learning systems, highlighting the model's effectiveness in predicting technology adoption in educational settings. These studies underscore the relevance of TAM for examining how students perceive and accept M-learning tools, providing a theoretical foundation for exploring their effectiveness in economics education.

The integration of mobile learning (M-learning) tools into economics education has garnered significant attention in recent years. However, a notable gap remains, particularly in identifying the effects of M-learning tools on local students' performance and self-directed learning capabilities in economics education. While many studies have explored active learning strategies in economics education, such as problem-based learning and cooperative learning, the role of M-learning tools in fostering these strategies has not been extensively investigated (Behal, 2024). Additionally, the effectiveness of M-learning in enhancing students' comprehension and retention in economics subjects remains underexplored. Addressing this gap is crucial for educators to know the impacts of integrating M-learning tools on their students' performance and self-directed learning capabilities in economics subjects.

The primary aim of this study is to:

Investigate the impact of M-learning tools on economics subjects.

- Evaluate the effects of M-learning on students' academic performance.
- Examine how M-learning tools influence students' comprehension of economic concepts.
- Explore students' engagement with course materials through M-learning tools.
- Assess how M-learning tools contribute to fostering students' self-directed learning capabilities.

2. Literature Review

2.1. M-Learning and Student Performance

In a self-directed learning (SDL) academic environment, students are given the autonomy to decide what, when, and how they learn and from whom. Does M-Learning impede or enhance educational achievement through SDL? Wan Mohd Isa et al. (2017) attempt to answer this question. A study on 190 learners was conducted. The results demonstrate that mobile learning tools help promote SDL capabilities. Hurst (2024) corroborated these findings by exploring the impacts of M-Learning tools on Brazilian college students through SDL. In their qualitative study, they found that M-learning tools positively affect college students by fostering students' learning autonomy and educational experience.

Therefore, M-learning supports collaborative and social learning environments, encouraging students' interaction with peers and instructors, enhancing motivation, and fostering accountability for learning (Maketo et al., 2021). In conclusion, many studies have highlighted the positive impacts of M-learning tools on the development of digital literacy and self-regulation capabilities, which are crucial for lifelong learning and career advancement (Al-Adwan, 2022; Karimi, 2016). By integrating M-learning tools, students are provided with modern tools and opportunities to manage their own learning, enhancing their ability to acquire and apply knowledge in a rapidly evolving digital world (Lee & Jeon, 2020).

2.2. M-Learning and Students' Self-Directed Learning

In a self-directed learning (SDL) environment, students are given the autonomy to decide what, when, and how they learn, as well as from whom they learn. Whether M-learning impedes or enhances educational achievement through SDL remains a contested question. Wan Mohd Isa et al. (2017) attempted to address this issue through a study involving 190 learners, reporting that mobile learning tools promote SDL capabilities. However, the study relied primarily on self-reported data, which may inflate perceived benefits due to response bias. Hurst (2024) corroborated these findings in the Brazilian higher education context, showing that M-learning fosters autonomy and enriches students' learning experiences. However, as a qualitative investigation, the generalisability of these results may be limited, especially in learning environments with varying levels of digital access and cultural expectations regarding autonomy.

Additionally, while Maketo et al. (2021) argue that M-learning supports collaborative and social learning environments by enhancing interaction with peers and instructors, such outcomes may depend heavily on students' digital readiness, instructors' technological competence, and institutional support—factors that are not consistently addressed across studies. Some scholars have also cautioned that constant digital interaction may fragment attention or overwhelm less digitally skilled learners, which challenges the assumption that M-learning universally enhances SDL.

In conclusion, although numerous studies highlight the positive role of M-learning in developing digital literacy and self-regulation skills essential for lifelong learning and career readiness (Karimi, 2016; Al-Adwan, 2022), these findings should be interpreted with caution. The effectiveness of M-learning in supporting SDL is shaped by contextual variables such as socio-economic disparities, device quality, learning culture, and instructional design. Thus, while M-learning can enhance students' capacity to manage their own learning in a rapidly evolving digital landscape (Lee & Jeon, 2020), its impact is not universally positive and may vary across different educational environments.

3. Theoretical Frameworks

3.1. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is a widely recognized theoretical framework used for understanding users' acceptance of technology. Originally developed by Davis (1989), TAM is rooted in the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975) and aims to explain and predict technology adoption by assessing users' perceptions and attitudes. The model has been extensively used in various fields, including education, healthcare, and business, to evaluate factors influencing the adoption of emerging technologies.

In this study, M-learning tools are integrated into the economics subjects' teachers' lessons. The tools encompass online games and other software. Students are permitted to use various mobile devices. The chosen areas have reliable internet access. The selected games are easily accessible to the students. The M-learning tools are selected based on the four key dimensions: (i) alignment with educational curriculum (DSKP), (ii) relevance to students' social and technological habits, (iii) cost-effectiveness, and (iv) ease of use, functionality, and safety (Sarrab, 2015).

3.2. Self-Directed Learning

Self-directed learning is the confidence in one's ability to manage academic tasks, responsibilities, and activities independently (Farah Wazera Mohamed Jaafar Sadiq & Mohammad Mujaheed Hassan, 2021). Previous studies have demonstrated that game-based learning enhances self-directed learning, including the integration of Word Wall media games into history education (Len et al., 2021) and the usability of the MyArabiy Game for Arabic language learning in JAIS religious schools (Zainuddin et al., 2021). Similarly, the game in M-Learning tools is expected to enhance students' self-directed learning in economics.

This study evaluates self-directed learning using the Self-Regulated Learning (SRL) model, introduced by Zimmerman (1989) and further developed by scholars such as Bandura (1991) and Boekaerts (1997). The model comprises three main phases: planning, execution, monitoring, and reflection, incorporating key elements such as student autonomy, learning goals, self-regulation strategies, and self-efficacy (Pintrich, 2000). Widely applied in education, SRL fosters independent learning and encourages students to seek knowledge proactively. Thus, this model is employed to assess students' level of self-directed learning after engaging with M-Learning Tools in the economics subject. The framework highlights three core elements: self-regulation, initiative-taking, and collaborative strategies, which form the foundation of self-directed learning integration within the SRL model.

4. Methodology

The quasi-experimental non-equivalent groups pre-test post-test design is employed to assess the impact of programs, activities, instructional methods, and other interventions, as recommended by Ghazali and Sufean (2021). The sample consists of 56 secondary school economics students in

Kuala Lumpur who are participating in the Bring Your Own Device (BYOD) program. This sample size reflects the total number of eligible students available within the program, given practical constraints in participant recruitment. Although relatively small for comparative experimental studies, the sample size indicated by a priori power analysis is sufficient to detect medium effect sizes (Cohen's d = 0.5) with 80% power at a 0.05 significance level. Nevertheless, the findings should be interpreted with caution, and future studies with larger and more diverse samples are recommended to confirm these results. The participants' demographic information is also provided below. These demographics indicate no significant effect or bias, as the participants are comparable in background, with similar levels of education and knowledge.

Table 1. Quasi-experimental non-equivalent groups pre-test post-test design

Group	Pre-test	Intervention	Post-test
Treatment	O_1	X_1	O_2
Control	O_1	X_2	O_2

O_1 = Pre-test before the given treatment
X_1 = M-Learning Tools
X_2 = Conventional Method
O_2 = Post-test after a given treatment

Table 2. Demographic of Participant

Participant	Female	Male	Age
Treatment group	16	10	16 yrs
Control Group	15	11	16 yrs

The data collection instruments consist of a set of questionnaires to assess respondents' self-directed learning level. Another research instrument is a set of questions to evaluate the respondents' performance in the economics subject. Both instruments demonstrated good internal consistency, with reliability coefficients of 0.797 or higher. The data in this study were analyzed using a paired t-test and descriptive analysis. Descriptive analysis includes percentages, means, and standard deviations (Foster et al., 2015). The interpretation of the mean scores in this study follows Nunnally and Bernstein (1994) (see Table 3). The findings were interpreted based on the majority of students' agreement or disagreement with the elements being studied.

Table 3. Interpretation of Mean Scores

Scale	Interpretation
1.00-2.00	Low
2.01-3.00	Moderately Low
3.01-4.00	Moderately High
4.01-5.00	High

Besides, the reliability of the questionnaire was assessed using internal consistency. According to Zuraini et al. (2022), internal consistency assumes that a reliable instrument measures only one construct. Reliability was determined using Cronbach's Alpha, calculated through SPSS. An alpha value below .60 indicates low reliability, while an excessively high value (above .95) suggests item redundancy. The ideal range is between 0.65 and 0.95. A pilot test was conducted at a school to evaluate the instrument's reliability. The results showed high Cronbach's Alpha values across all questionnaire items, confirming its suitability for the study. Table 4 presents the alpha coefficients for each element.

Table 4. Questionnaire Alpha Coefficient Values

Element	Cronbach's Alpha
Motivation	0.914
SDL	0.797

The M-learning intervention was implemented over a period of six weeks at the school. Sessions were scheduled for one hour per day, twice a week, providing a total of 12 hours of instruction. A single teacher, experienced and proficient with the educational game, conducted all sessions. By clearly outlining the duration, frequency, and personnel involved, as well as the specific digital tool employed, this study provides sufficient procedural details to enhance the replicability of the intervention and facilitate the interpretation of the findings.

Ethical considerations were strictly followed throughout the study. Teachers received guidance prior to administering the pre-test and post-test, ensuring that the procedures were clearly understood. Students were briefed on the purpose and process of the study before participation. Online consent forms were distributed to participants, and both the school administration and parents were informed about the study. Participants were assured of the confidentiality of their responses and their right to withdraw at any time without any consequences. These measures ensured that the study adhered to established ethical guidelines for educational research.

The M-learning intervention involved a game that was easily accessible via the Play Store, which students downloaded to their own devices. Each session lasted 30 minutes and was conducted twice a week. The teacher acted solely as a mentor, guiding without direct instruction. The BYOD program allowed students to bring their own devices to school under school supervision, offering flexibility and convenience. However, variations in device quality and potential distractions should be acknowledged as limitations.

The effectiveness of the M-learning intervention was evaluated using pre-test and post-test exam scores. Pre-test scores were collected before the implementation of the educational game, and post-test scores were collected after a one-month intervention period. Descriptive statistics, including the number of participants (N), mean, and standard deviation (SD), were calculated to summarize the overall performance and variability of students' scores. To examine whether the intervention had a statistically significant effect on students' performance, a paired-samples t-test was conducted. Prior to conducting the t-test, assumptions of normality and homogeneity of variance were checked. Normality of the pre-test and post-test scores was assessed using the Shapiro-Wilk test, and the data were approximately normally distributed. The assumption of homogeneity of variance was considered satisfied, as required for the t-test. The significance level was set at 0.05. By presenting both descriptive and inferential statistics, the analysis provides a clear understanding of the intervention's impact and allows for appropriate interpretation of the results.

The study employed a 20-item questionnaire divided into three sets, administered at different times depending on the topic being assessed. A 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) was used to measure students' motivation and self-directed learning, with 15 items specifically targeting these constructs. Mean scores were calculated and interpreted according to the scale, enabling a clear understanding of participants' levels of motivation and self-regulation. This specification of the scale type ensures transparency and facilitates accurate interpretation of the questionnaire results.

https://doi.org/10.22521/edupij.2026.22.40 Published online by Universitepark Press

The self-directed learning measurement tool used in this study was adapted from Mahathir's (year) thesis on Web-Based Learning. The adaptation process involved modifying items to suit the context of the M-learning intervention and the secondary school economics curriculum. Educational experts reviewed the adapted questionnaire to ensure content validity and clarity, and a pilot test was conducted to confirm its reliability and appropriateness for the target participants. This process ensures that the measurement instrument accurately captures students' motivation and self-directed learning capabilities in the context of the study.

5. Results

In this study, the researchers need to ensure that four key assumptions are met: measurement scale, variable measurement, normality, and homogeneity of variance. Additionally, a normality test was conducted to assess whether the data were normally distributed. Based on Table 5, the respondents' scores exhibit a normal distribution, as the Skewness and Kurtosis values fall within the range of +1.96 to -1.96 (Chua, 2012).

Table 5. Normality Test using Skewness and Kurtosis

Test	Group	Pre-test		Post-test	
		Skewness	*Kurtosis*	*Skewness*	*Kurtosis*
Student Achievement	Control Group	0.178	-0.973	0.023	-0.911
	Treatment Group	0.407	-4.59	0.129	-0.846
Student Self-Directed Learning	Control Group	-0.420	-0.135	-0.516	-0.300
	Treatment Group	-0.91	-0.913	-0.200	0.059

5.1. Respondents' Performance

The next test aimed to evaluate the respondents' performance in the pre-test. This assessment was conducted to test hypothesis H01, which states that there is no significant difference in the mean performance scores between the control and treatment groups. Ho1 is using the paired t-test. Additionally, this test aimed to ensure that the students' proficiency levels were almost equal.

The findings of the study indicate that the mean pre-test scores for the control and treatment groups were 51.286 and 48.179, respectively, as presented in Table 6. Descriptively, the control group outperformed the treatment group. The analysis further revealed a t-value of 0.996 and a significance value of 0.328 ($p > 0.05$). Since the p-value exceeded the alpha level of 0.05, H01 could not be rejected. This suggests that there was no significant difference in the performance of students in the control group compared to those in the treatment group in the pre-test.

Table 6. The result of the achievement pre-test for the control and treatment groups

Group	N	Mean	Std. Deviation	t	df	*Sig*
Control Group	28	51.286	11.731	0.996	27	0.328
Treatment Group	28	48.179	13.160			

*Note: ** significance level at 0.05*

To identify the impacts of the M-learning tool on students' achievement, the researcher aimed to test the hypothesis H02: There is no significant difference in the mean post-test performance scores between the control and treatment groups. A paired t-test was conducted to assess the difference in mean scores between the two groups.

The findings indicate that the mean post-test scores for the control and treatment groups were 58.286 and 70.179, respectively, as presented in Table 7. Descriptively, the treatment group outperformed the control group. The analysis further revealed a t-value of -3.580 and a significance value of 0.001 ($p < 0.05$). Since the p-value was less than 0.05, the null hypothesis H02 was statistically rejected. This indicates a significant difference in achievement between the control and treatment groups on the post-test.

Table 7. The results of the achievement post-test for the control and treatment groups

Group	N	Mean	Std. Deviation	t	df	*Sig*
Control Group	28	58.286	11.118	-3.580	27	0.001
Treatment Group	28	70.179	15.263			

*Note: ** significance level at 0.05*

5.2. Self-Directed Learning Capabilities

The report continues with findings addressing hypothesis H03, which states that there is no significant difference in the mean self-directed learning levels of students in the pre-test between the control and treatment groups. The evaluation aimed to determine the students' self-directed learning capabilities before the intervention was conducted in both groups.

The findings indicate that the mean pre-test scores for the control and treatment groups were 3.107 and 3.112, respectively, as presented in Table 8. Descriptively, the treatment group showed slightly better results than the control group. The analysis also revealed a t-value of -0.046 and a significance value of 0.964 ($p > 0.05$). Since the p-value exceeded 0.05, hypothesis H03 was statistically accepted. This suggests that there was no significant difference in self-directed learning levels between the control and treatment groups in the pre-test. This finding confirms that the self-directed learning levels of students in both groups were equal before the intervention.

Table 8. The results of the self-directed learning pre-test for the control and treatment groups

Group	N	Mean	Std. Deviation	t	df	*Sig*
Control Group	28	3.107	0.472	-0.046	27	0.964
Treatment Group	28	3.112	0.303			

*Note: ** significance level at 0.05*

To examine the impact of students' self-directed learning capabilities using M-learning tools, the researchers aimed to test hypothesis H04, which states that there is no significant difference in the mean self-directed learning levels of students in the post-test between the control and treatment groups. A paired t-test was used to analyze the difference in mean scores between the respondents from the two groups.

The findings indicate that the mean post-test scores for the control and treatment groups were 3.480 and 4.077, respectively, as presented in Table 9. Descriptively, the treatment group once again outperformed the control group. The analysis revealed a t-value of -4.331 and a p-value < 0.001 ($p < 0.05$). Since the p-value was less than 0.05, the null hypothesis H04 was statistically rejected. This indicates a significant difference in self-directed learning capabilities between the control and treatment groups on the post-test.

Table 9. The results of the self-directed learning post-test for the control and treatment groups

Group	N	Mean	Std. Deviation	t	df	*Sig*
Control Group	28	3.480	0.531	c	27	<0.001
Treatment Group	28	4.077	0.535			

*Note: ** significance level at 0.05*

The test results clearly indicate that the M-learning tool for the economics subject has positive impacts on students' achievement and self-directed learning capabilities. This conclusion is supported by the pre-test findings, which show that both the control and treatment groups started at almost the same level. However, after the intervention, the treatment group showed significantly greater improvement in scores than the control group. These results provide strong evidence of the positive impact of M-learning tools on students' learning performance in economics subjects.

6. Discussion

The findings of this study highlight the effectiveness of M-learning tools in improving students' academic performance and self-directed learning capabilities in economics education. The results revealed a significant increase in post-test scores among students who utilized M-learning tools compared to those who studied using traditional learning approaches. This suggests that integrating M-learning tools into economics education can enhance students' engagement and comprehension of complex economic concepts. The findings are aligned with many previous studies indicating that mobile learning fosters interactive and personalized learning experiences, which contribute to better student retention and comprehension (Crompton, H., 2018).

One of the key outcomes observed in this study is the positive impact of M-learning tools on students' self-directed learning capabilities. Students in the treatment group demonstrated higher levels of self-regulation and autonomy in managing their learning compared to the control group. These findings support the notion that M-learning environments encourage self-directed learning by providing flexible access to educational materials, thereby allowing students to learn at their own pace and from any location (Jeno et al., 2019). The increase in self-directed learning scores suggests that M-learning tools can facilitate a shift from teacher-centered instruction to student-driven learning experiences, an essential component for learning success in higher education (Law & Niu, 2019).

Furthermore, the study highlights the roles of interactive and gamified features in M-learning tools in enhancing student motivation. The use of online quizzes, real-time feedback, and digital simulations in the M-learning tools helped maintain students' motivation and engagement throughout the learning process. Previous studies have similarly indicated that incorporating online gamification can increase students' motivation and engagement (Lazarinis & Kanellopoulos, 2021). The findings emphasize the importance of designing M-learning tools with interactive elements.

Despite these benefits, the challenges associated with the implementation of M-learning tools need to be acknowledged and addressed. This study identified several barriers to effective adoption, including technological constraints such as unreliable internet connectivity, device compatibility issues, and data security concerns. These findings are consistent with existing literature highlighting that technological and infrastructural challenges can impede the successful integration of M-learning tools in education (Garzón et al., 2024). Addressing these challenges requires institutional support for infrastructure development and digital literacy training for both students and educators.

Another noteworthy consideration is the potential for increased screen time, which may affect students' physical and mental health. Excessive use of mobile devices for learning can lead to issues such as eye strain and reduced physical activity, which means a balanced approach to M-learning implementation should be considered (Garzón et al., 2024). Future research should explore strategies to mitigate these concerns while maintaining the advantages of mobile-based learning.

7. Conclusion

In conclusion, this study affirms the positive impacts of mobile learning (M-learning) tools on students’ academic performance and self-directed learning capabilities in economics education. While mobile technologies offer promising opportunities for enhancing learning, successful integration into classroom practice requires thoughtful planning and addressing implementation challenges. Future research should investigate the long-term effects of M-learning tools and develop strategies for their sustainable integration into diverse curricular contexts.

From a theoretical standpoint, the findings support the Technology Acceptance Model (TAM), which asserts that perceived usefulness and ease of use shape learners’ acceptance of digital tools. The students in this study perceived M-learning tools as both accessible and beneficial, reinforcing TAM’s relevance in secondary school settings. Additionally, the Self-Regulated Learning (SRL) framework helps explain the observed increase in students’ abilities to set learning goals, monitor their progress, and take ownership of their academic development. These behaviors signal a move toward greater learner autonomy and internal motivation.

8. Suggestion

The implications of this shift extend beyond the economics classroom. Educators and policymakers should consider how M-learning can foster equitable, inclusive, and student-centered learning cultures across various subjects and educational levels, especially in under-resourced contexts where traditional learning may be limited.

Declarations

Author Contributions. This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name Of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Mohd Zaim Zainal Adnan	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Mohamad Zuber Abd Majid	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nofouz Mafarja	✓			✓			✓			✓				
Maslawati Mohamad	✓				✓		✓			✓				
Aidah Abdul Karim	✓									✓				
Nur Fadzlunnisaa’ Wakimin	✓			✓						✓				

C: Conceptualization
M: Methodology
So: Software
Va : Validation
Fo: Formal analysis
I: **I**nvestigation
R: **R**esources
D: **D**ata Curation
O: Writing - **O**riginal Draft
E: Writing - Review & **E**diting
Vi: **V**isualization
Su: **S**upervision
P: **P**roject administration
Fu: **F**unding acquisition

Conflicts of Interest. The authors declare that they have no competing interests.

Funding. The Universiti Kebangsaan Malaysia supported this work under the research grant of GG-2024-032.

Data Availability Statement. The data supporting the findings of this study are available from the corresponding author [MZAM], upon reasonable request.

Acknowledgments. During the preparation of this work, the author(s) used an AI tool (e.g., Grammarly / ChatGPT) to assist with translating the text into English and improving grammar and sentence structure. The author(s) declare that they reviewed and edited the final output as needed and take full responsibility for the content of the published article.

References

Al-Adwan A. S., N. M. A. H. A. N. A. & A.-O. M. (2022). Towards a sustainable adoption of e-learning systems: The role of self-directed learning. *Journal of Information Technology Education: Research*, *21*, 1–18. https://doi.org/10.28945/4954

Al-Emran M., E. H. M. & S. K. (2016). Investigating attitudes towards the use of mobile learning in higher education. *Computers in Human Behavior*, *56*, 93–102.

Al-Okaily M., A. H. M. A. L. A. & T. A. (2020). Dataset on the acceptance of the e-learning system among university students under the COVID-19 pandemic conditions. *Data in Brief*, *32*, Article 106176. https://doi.org/10.1016/j.dib.2020.106176

Al-Rahmi A. M., A.-R. W. M. A. U. A. A. A. S. & A.-A. A. S. (2022). Acceptance of mobile technologies and M-learning by university students: An empirical investigation in higher education. *Education and Information Technologies*, *27*(6), 7805–7826. https://doi.org/10.1007/s10639-022-10934-8

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, *50*(2), 248–287. https://doi.org/https://doi.org/10.1016/0749-5978(91)90022-L

Bano M., Z. D. K. M. S. S. & A. P. (2018). Mobile learning for science and mathematics school education: A systematic review of empirical evidence. *Computers & Education*, *121*, 30–58.

Behal, M. (2024). Pedagogical strategies in economic education: Fostering active learning. *Journal of Economics and Economic Education Research*, *25*(5), 1–3.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and Instruction*, *7*(2), 161–186. https://doi.org/10.1016/S0959-4752(96)00015-1

Chua, Y. P. (2012). *Quantitative research: A guide for beginners*. McGraw-Hill Education.

Crompton, H., & B. D. (2018). The use of mobile learning in higher education: A systematic review. *Computers & Education*, *123*, 53–64.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

De-Marcos L., H. J. R. B. R. J. L. M. J. J. G. J. A. & O. S. (2010). An experiment for improving students' performance in secondary and tertiary education by means of m-learning auto-assessment. *Computers & Education*, *55*(3), 1069–1079. https://doi.org/10.1016/j.compedu.2010.03.011

Farah Wazera Mohamed Jaafar Sadiq, & Mohammad Mujaheed Hassan. (2021). Konsep kendiri dan gaya pembelajaran terhadap motivasi akademik dalam kalangan mahasiswa. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *6*(2), 75–105. https://msocialsciences.com/index.php/mjssh/article/view/683

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Addison-Wesley.

Foster, T., Diamond, A., & Jefferies, P. (2015). Reliability and validity of data collection instruments in educational research. *Educational Measurement: Issues and Practice*, *34*(1), 34–42. https://doi.org/10.1111/emip.12052

Garzón, J., Kinshuk, B., D., & Tlili, A. (2024). Advantages and challenges associated with mobile learning in education: A systematic literature review. *Journal of Computers in Education*. https://doi.org/10.1007/s40692-024-00342-x

Ghazali, Z., & Sufean, H. (2021). The effectiveness of quasi-experimental designs in educational research: Assessing instructional methods and interventions. *Journal of Educational Research and Practice*, *12*(2), 98–112. https://doi.org/10.1016/j.jer.2021.02.004

Hurst, R. A. (2024). Analysis of the impact of personalized learning paths in mobile learning platforms on the development of self-directed learning strategies among Brazilian college students. *Research and Advances in Education*, *3*(3), 9–14. https://doi.org/10.1680/rae.3.3.9

Ifeanyi, A. I., & Chukwuere, J. E. (2018). The impact of using smartphones on the academic performance of undergraduate students. *Knowledge Management \& E-Learning*, *10*(3), 290–308.

Ishak, N., Din, R., & Othman, N. (2022). Teachers' perceptions and challenges to the use of technology in teaching and learning during COVID-19 in Malaysia. *International Journal of Learning, Teaching and Educational Research*, *21*(5), 15–30. https://doi.org/10.26803/ijlter.21.5.15

Jeno, L. M., Adachi, P. J. C., Grytnes, J. A., Vandvik, V., & Deci, E. L. (2019). The effects of m-learning on motivation, achievement, and well-being: A Self-Determination Theory approach. *British Journal of Educational Technology*, *50*(2), 669–683. https://doi.org/10.1111/bjet.12657

Karimi, S. (2016). Do learners' characteristics matter? An exploration of mobile-learning adoption in self-directed learning. *Computers in Human Behavior*, *63*, 769–776. https://doi.org/10.1016/j.chb.2016.05.030

Kim, S., & Park, S. (2019). The effect of smartphone-based mobile learning on nursing education: A meta-analysis. *Computers, Informatics, Nursing*, *37*(12), 638–645.

Klimova, B. (2019). Impact of mobile learning on students' achievement results. *Education Sciences*, *9*(2), 90.

Law, K. M. Y., & Niu, J. (2019). Investigating self-directed learning and technology readiness in blending learning environment. *International Journal of Educational Technology in Higher Education*, *16*(1), 17. https://doi.org/10.1186/s41239-019-0147-0

Lazarinis, F., & Kanellopoulos, D. (2021). Fostering student engagement in a mobile formative assessment system for high-school economics. *Education and Information Technologies*, *26*(3), 3215–3233.

Lebedeva, M., Taranova, M., & Beketov, V. (2023). Assessment of academic achievements in m-learning. *Education and Information Technologies*, *28*(5), 5945–5965.

Lee, E. Y., & Jeon, Y. J. J. (2020). The difference of user satisfaction and net benefit of a mobile learning management system according to self-directed learning: An investigation of cyber university students in hospitality. *Sustainability*, *12*(7), 2672.

Len, R., Woei, J., Bikar, S. S., Rathakrishnan, B., & Rabe, Z. (2021). *Integrasi Permainan Media Word Wall dalam Pendidikan Sejarah Abstrak Integration of Word Wall Games in History Education*. *6*(4), 69–78.

Lusardi, A. (2019). Financial literacy and the need for financial education: evidence and implications. *Swiss Journal of Economics and Statistics*, *155*(1), 1–8.

Maketo, L., Issa, T., Issa, T., & Nau, S. Z. (2021). M-Learning Impact on Self-Directed Learning In Zimbabwe Higher Education. *Mobile Learning 2021 and Educational Technologies 2021*, 220–224.

Mehdipour, M., & Zerehkafi, H. (2013). Mobile learning for education: Benefits and challenges. *International Journal of Computational Engineering Research*, *3*(6), 93–101.

Nkosi, S. S., Sibanda, R., & Katrodia, A. (2019). Mobile technology as a learning tool in the academic environment. *Journal of Economics and Behavioral Studies*, *11*(2), 92–102.

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). McGraw-Hill.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In *Handbook of self-regulation.* (pp. 451–502). Academic Press. https://doi.org/10.1016/B978-012109890-2/50043-3

Rangel-de Lázaro, G., Martínez, M. S., & Duart, J. M. (2023). Moving Learning: A Systematic Review of Mobile Learning Applications for Online Higher Education. *Journal of New Approaches in Educational Research*, *12*(2), 206–221.

Saikat, S., Dhillon, J. S., Ahmad, W. F. W., & Jamaluddin, R. A. (2021). A systematic review of the benefits and challenges of mobile learning during the COVID-19 pandemic. *Education Sciences*, *11*(9), 459. https://doi.org/10.3390/educsci11090459

Sarrab, M. (2015). M-learning in education: Mobile learning applications for the education sector. *International Journal of Advanced Computer Science and Applications (IJACSA)*, *6*(4), 9–15. https://doi.org/10.14569/IJACSA.2015.060404

Shuja, A., Qureshi, I. A., Schaeffer, D. M., & Zareen, M. (2019). Effect of M-Learning on Students' Academic Performance Mediated by Facilitation Discourse and Flexibility. *Knowledge Management \& E-Learning*, *11*(2), 158–200.

Sung, Y. T., Chang, K. E., & Liu, T. C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers \& Education*, *94*, 252–275.

Talan, T. (2020). The effect of mobile learning on learning performance: A meta-analysis study. *Educational Sciences: Theory and Practice*, *20*(1), 79–103.

Valero, A., & Van Reenen, J. (2019). The economic impact of universities: Evidence from across the globe. *Economics of Education Review*, *68*, 53–67.

Wan Mohd Isa, W. A. R., Zulkipli, Z. A., & Mustapa, M. N. (2017). A conceptual framework of blended learning for self-directed learners in the social context: case of mobile learning. *Social and Management Research Journal (SMRJ)*, *14*(1), 51–64.

Wang, J. (2024). Innovations in economics education: Leveraging technology for student engagement. *Journal of Economics and Economic Education Research*, *25*(S6), 1–3.

Weichhart, G., Stary, C., & Appel, M. (2018). The impact of mobile learning on students' learning behaviors and performance: Report from a large-scale evaluation. *International Journal of Mobile and Blended Learning*, *10*(1), 45–60.

Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M. J. P., & Loyens, S. M. M. (2024). The Effects of Problem-Based, Project-Based, and Case-Based Learning on Students' Motivation: a Meta-Analysis. *Educational Psychology Review*. https://doi.org/10.1007/s10648-024-09864-3

Zainuddin, G., Ramlan, S. R., Masrop, N. A. M., bin Sahrir, M. S., & bin Abdullah, E. (2021). Teachers' Perspectives on Digital Game-Based Language Learning for Arabic Language in Malaysian

Primary Schools. *Proceedings of the 4th International Conference on Sustainable Innovation 2020–Social, Humanity, and Education (ICoSIHESS 2020)*. https://doi.org/10.2991/ASSEHR.K.210120.157

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, *81*(3), 329–339. https://doi.org/10.1037/0022-0663.81.3.329

About the Contributor(s)

Mohd Zaim Zainal Adnan is a master's student at Universiti Kebangsaan Malaysia, brings 12 years of teaching experience. Recognized as a state-level innovative and iconic educator, he is committed to educational innovation. Specializing in gamified economics education, he is earned a gold award for his pioneering contributions to teaching methods. He can be contacted through email:.
Email: mzaimzainal@gmail.com
ORCID: https://orcid.org/0009-0009-5290-3264

Mohamad Zuber Abd Majid (PhD) is an educationist in economics from Universiti Kebangsaan Malaysia, Selangor, who is currently serving in the Center of Innovation Teaching and Learning, Faculty of Education, Universiti Kebangsaan Malaysia. He is actively involved in research in sustainability in economic resources, human capital and disability, and applied economics in technical vocational education and training (TVET), employability, and career readiness.
Email: mzuber@ukm.edu.my
ORCID: https://orcid.org/0000-0001-5434-5926

Nofouz Mafarja (PhD) is senior lecturer at the Department of Mathematics and Science Education, Faculty of Education, University of Malaya. Her research focuses on physics education, scaffolding in education, collaborative learning (reciprocal teaching strategy), word problem solving in physics, critical thinking skills, STEM Education, academic self-concept, attitude learning physics, reading comprehension in science, and research methodology. She is presently involved in several research projects on Industrial Revolution 4.0, teaching innovation, learning support, virtual reality, hybrid learning system, PjBL model, society 5.0, critical thinking skills, generative AI tools, and teaching practices. She had experience in teaching sciences, curriculum development, educational technology, tutoring, educational leadership, science, and teacher training.
Email: nofouz@um.edu.my
ORCID: https://orcid.org/0000-0001-7367-3431

Maslawati Mohamad (PhD) has 27 years of experience in the field of TESL. She has conducted various training sessions in the field for both the government and private sectors. Her areas of expertise include teaching and learning innovation, reading in the ESL context, and English for specific purposes. She is currently a senior lecturer at the Faculty of Education, UKM.
Email: maslawati@ukm.edu.my
ORCID: https://orcid.org/0000-0002-8979-5895

Aidah Abdul Karim (PhD) is a Senior Lecturer at the Faculty of Education, Universiti Kebangsaan Malaysia (UKM). She holds a Bachelor of Economics (BEcons), a Master of Library and Information Science (MLIS) from the International Islamic University Malaysia, and a PhD from Auckland University of Technology, New Zealand. Her academic and research interests focus on information and resource management, educational technology, and the integration of computers in teaching and learning.
Email: eda@ukm.edu.my
ORCID: https://orcid.org/0000-0002-1115-1205

Nur Fadzlunnisaa' binti Wakimin (PhD) is a Senior Lecturer at the Faculty of Economics, Universiti Malaysia Sabah (UMS). She is an expert in economics, economic growth, tourism, and the environment, with research interests also covering panel data econometrics and development economics. Besides her academic role, she is actively involved in associational activities, social services, co-curricular programs, and research.
Email: fadzlunnisaa@ums.edu.my
ORCID: https://orcid.org/0000-0002-8233-4957