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The influence of online learning readiness on mathematics achievement with mathematics self-efficacy as an intervening variable

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Abstract

Background: The impact of online learning during the pandemic on students' mathematics achievements is influenced by their preparedness and belief in their ability to learn mathematics. Students' readiness is closely linked to their self-efficacy.

Aim: This study aims to examine the influence of online learning readiness on mathematics achievement, with mathematics self-efficacy serving as a mediator.

Method: The study adopted a quantitative exploratory correlational approach to statistically explore the relationships between variables. It involved 197 students from UIN Sultan Aji Muhammad Idris Samarinda, who were enrolled in mathematics courses and selected through convenience sampling. Data were collected using an online learning readiness questionnaire and a mathematics self-efficacy scale, with final semester grades indicating mathematics learning achievement. Path analysis was utilized for data analysis.

Result: The findings reveal that both online learning readiness and mathematics self-efficacy have a partial and simultaneous effect on mathematics learning achievement. Additionally, online learning readiness influences mathematics self-efficacy. The Sobel test results indicate that mathematics self-efficacy mediates the relationship between online learning readiness and mathematics learning achievement, with a more dominant direct influence of online learning readiness on mathematics achievement.

Conclusion: The study underscores the importance of a student-oriented approach in online learning, considering the significant role of online learning readiness and self-efficacy in enhancing mathematics learning achievement.

INTRODUCTION

The development of information technology provides excellent opportunities for learning anywhere and anytime online. Online learning has several conveniences and advantages compared to offline learning (Ni Fhloinn & Fitzmaurice, 2021; Sukma & Priatna, 2021). Online learning provides students with the flexibility to manage their time between studying and other activities, allows for more time to understand a subject in greater details as it can be repeated and performed anywhere (Andriyati et al., 2022; Daniel et al., 2016; Fajar & Larasati, 2022). Additionally, online learning enhances student communication, interaction, and collaboration (Kumar et al., 2021). These advantages and conveniences positively impact students' achievements during online learning (Clark et al., 2021; Clark & Whetstone, 2014; Tezer et al., 2019).

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However, at the same time, online learning presents challenges in mathematics education. A study by Juan et al. (2011) stated that teaching complex mathematical concepts asynchronously is less interactive than face-to-face interaction, which may hinder students understanding. Additionally, teachers face difficulties monitoring students' competency achievements during online learning (Andriyati et al., 2022). From a technical perspective, challenges in online learning include issues such as network support, internet access, availability of devices and proficiency in using them, as well as the availability of suitable learning spaces (Aien et al., 2020; Baticulon et al., 2021; Bringula et al., 2021; Fabito et al., 2020; Fatmahanik, 2021). These challenges contribute to lower mathematics achievement among students in online learning settings (Ariyanti & Santoso, 2020; Mahfud et al., 2021; Tambunan, 2021). Thus, online mathematics learning can positively or negatively impact students' mathematical abilities, depending on various online learning characteristics.

The inconsistency of the impact of online mathematics learning on students' mathematics achievement can be explained by the implementation period. When comparing the timeline of research on online mathematics education, it is found that most ineffective online mathematics learning experiences occurred during the Covid-19 pandemic (Ariyanti & Santoso, 2020; Tambunan, 2021). The rapid spread of the virus forced teachers and students to quickly transit from offline to online learning without thorough preparation (Harris, 2020). Additionally, well-established online learning systems have demonstrated the effectiveness of online learning compared to offline learning (Kemp & Grieve, 2014; Meisami, 2020). This indicates that the benefits of online learning can only be fully realized when students are prepared to engage in it (Chung et al., 2020). Therefore, it is likely that preparedness for online learning becomes a determining factor in students' mathematics achievement during online learning.

Hung et al. (2010) concluded that students' online learning readiness includes self-directed online learning, motivation for online learning, self-efficacy in computer and internet use, learning control, and self-efficacy in online communication. These five indicators are related to learning achievement (Alotaibi & Alanazi, 2021; Grigg et al., 2018; León et al., 2015). Previous research has also shown that online learning readiness impacts learning achievement (Hamidy & Lam, 2022; Joosten & Cusatis, 2020). However, there are differences in the magnitude of the impact of online learning readiness on learning achievement. Specifically, Joosten & Cusatis (2020) even demonstrated that the self-efficacy aspect of online learning readiness has a more dominant influence on learning achievement. This suggests the hypothesis that online learning readiness affects mathematics achievement through self-efficacy.

Self-efficacy plays a crucial role in mathematics learning. Self-efficacy in mathematics learning is related to students' self-assessment of their abilities to solve mathematical problems (Grigg et al., 2018). The positive perception of self-ability leads to confidence, so students are more likely to approach math-related tasks with determination and enthusiasm, then positively impact the learning process. Therefore, self-efficacy in mathematics influences students' mathematics achievement (Grigg et al., 2018; Muhtadi et al., 2022; Verma & Bhandari, 2022).

As a predictor of mathematics achievement, other variables also influence students' self-efficacy (Kung & Lee, 2016; Liu et al., 2021; Rahmawati et al., 2022). One reference for students in assessing their ability to succeed in mastering mathematics is their readiness to learn. In the context of online learning, learning readiness, which includes the availability of

resources, mastery of skills, and supportive learning attitudes for online learning, can influence students' confidence in mastering the mathematics content taught in an online setting. This confidence affects students' self-assessment of their potential for success in mathematics learning (Verma & Bhandari, 2022). Self-efficacy in online learning is also a component of online learning readiness (Hung et al., 2010). Therefore, it is hypothesized that online learning readiness affects students' self-efficacy in mathematics. This is consistent with several previous studies that have shown the influence of preparedness for learning on students' self-efficacy (Bubou & Job, 2020; Turan & Koç, 2018; Warden et al., 2022).

The previous explanation shows that there is a relationship between online learning readiness, self-efficacy, and mathematics learning achievement. Online learning readiness is thought to have a direct and indirect effect on mathematics learning achievement through the mediating variable self-efficacy. This research presents novelty by focusing on a specific examination of the mediating role of mathematics self-efficacy in the relationship between online learning readiness and mathematics learning achievement. This aspect is particularly unique, considering that previous studies such as Kung & Lee (2016) and Sağkal & Sönmez (2022) have examined the mediating role of mathematics self-efficacy, but not in the context of online learning readiness on mathematics achievement. In addition, although Joosten & Cusatis (2020) support the significant influence of several characteristics of online learning readiness on learning outcomes, they do not explain in detail the mediating function of self-efficacy in this context. Hamidy & Lam's (2022) research also suggests testing the mediating function of mathematics self-efficacy in the relationship between online learning readiness and mathematics learning achievement. Therefore, this research aims to explain the relationship between these three variables so as to contribute to efforts to increase mathematics learning achievement in the online learning era.

METHODS

This study is exploratory correlational research (Creswell, 2012) with a quantitative paradigm. The relationship between online learning readiness, mathematics self-efficacy, and mathematics achievement is statistically examined. The relationship model used is a linear regression with a mediating variable, as shown in Figure 1. The participants of this study are 197 students taking Mathematics courses from UIN Sultan Aji Muhammad Idris Samarinda who were selected by convenience sampling technique. The distribution of participants based on several characteristics is presented in Table 1.

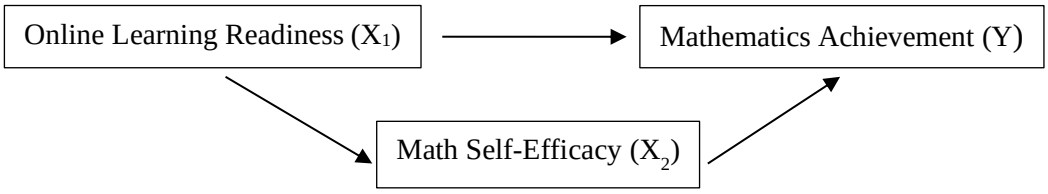

Figure 1. Research Model

Table 1. Participant Demography

Characteristic	N	%
Sex		
Male	46	23.40
Female	151	76.60
Academic Year		
First Year	37	18.80
Second Year	115	58.40
Third Year	45	22.80
Department		
Elementary Education	37	18.80
Economic and Business	160	81.20

Online learning readiness was measured using a questionnaire adapted from Hung et al. (2010). The indicators of online learning readiness included self-efficacy in computer and internet use, learning initiative, learning control, learning motivation, and self-efficacy in online communication. There was a total of 16 items using a Likert scale. After being piloted with 282 participants, the Confirmatory Factor Analysis (CFA) results indicated that all items were valid (0.500). The questionnaire instrument was considered reliable based on the Cronbach's Alpha coefficient (0.903).

Mathematics self-efficacy was measured using a questionnaire adapted from May (2009). The indicators of mathematics self-efficacy consisted of general mathematics self-efficacy, self-efficacy in achieving grades, self-efficacy in completing mathematical tasks, self-efficacy in future mathematics endeavors, and self-efficacy during classroom activities. There was a total of 29 items using a Likert scale. After piloting with 282 participants, the results of CFA indicated that one item was invalid and not used for further analysis. The questionnaire instrument was considered reliable based on the Cronbach's Alpha coefficient (0.888). Students' mathematics achievement was obtained from their final semester grades. The final grade comprised participation, assignments, mid-semester, and final exams. The final grades were measured on a scale of 1-100.

The data were analyzed using path analysis, which consisted of two regression models. The first regression model was used to analyze the influence of online learning readiness on self-efficacy. The second regression model was used to analyze the influence of online learning readiness and mathematics self-efficacy on mathematics achievement. The regression coefficients from each model were used to calculate the magnitude of the direct and indirect effects of online learning readiness on mathematics achievement, with mathematics self-efficacy as the mediating variable (Baron & Kenny, 1986). The mediating role of mathematics self-efficacy was tested using the Sobel test (Sobel, 1982).

RESULTS AND DISCUSSION

Result

The results of the first regression model are presented in Table 2. The first regression model indicates that online learning readiness significantly influences mathematics self-efficacy. Based on the regression coefficient, online learning readiness positively affects mathematics self-efficacy. The relatively high coefficient of determination (91.3%) suggests that online learning readiness has a dominant contribution to students' self-efficacy in learning mathematics.

The second regression model shows that online learning readiness and mathematics self-efficacy partially and simultaneously affect mathematics achievement. Based on the regression coefficients, both online learning readiness and mathematics self-efficacy positively impact students' mathematics achievement. The high coefficient of determination in the second regression model (98.3%) indicates that online learning readiness and mathematics self-efficacy are dominant variables influencing the variability of mathematics achievement. Based on the regression coefficients, the influence of online learning readiness is more considerable than that of mathematics self-efficacy on mathematics achievement.

Table 2. Path Analysis Result

	B	t	E	F	R^2
		First Regression Model			
X_1*	1,372	43,864***	0,031	1924.069***	0,913
		Second Regression Model			
X_1**	0,896	18,939***	0,047	5235,355***	0,983
X_2**	0,383	11,616	0,033		

* Dependent Variable: X_2
** Dependent Variable: Y
*** p < 0,01

Based on Table 2, the path coefficients of the relationship between online learning readiness, mathematics self-efficacy, and mathematics achievement can be presented in Figure 2.

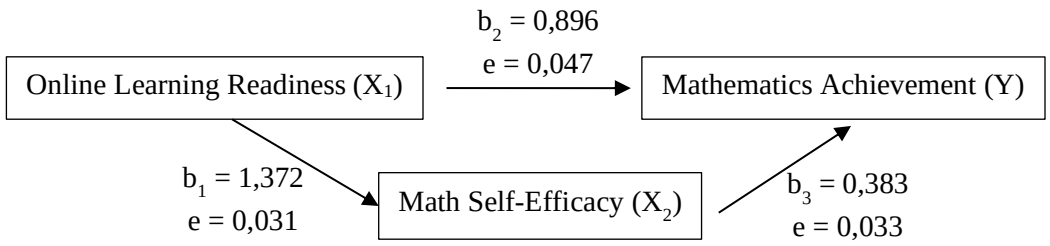

Figure 2. Path Coefficient

Based on the path coefficients in Figure 2, the indirect effect of online learning readiness on mathematics achievement through mathematics self-efficacy is 0.525. This indirect effect is lower than the direct effect (0.896). This indicates that the direct effect of online learning readiness on mathematics achievement is more dominant than the indirect effect mediated by mathematics self-efficacy. The results of the Sobel test show that mathematics self-efficacy significantly mediates the relationship between online learning readiness and mathematics achievement (Sobel test statistics = 11.226; $p < 0.01$).

Discussion

This study examines the influence of online learning readiness on mathematics achievement, with mathematics self-efficacy as the mediating variable. Data were collected through questionnaires on online learning readiness, mathematics self-efficacy, and students' final semester grades in mathematics courses. The collected data were then analyzed using path analysis to determine the magnitude of the direct and indirect effects and the significance of the mediating variable.

The first regression model shows that online learning readiness significantly influences mathematics self-efficacy. While the study by Bubou & Job (2020) provided the same effect in a broader area, this finding provides greater insight into the mathematics learning context. The better students' readiness for online learning, the more positively they assess their ability to solve mathematical problems in school. Online learning readiness includes the ability to use technology that supports online learning and self-directed learning (Hung et al., 2010). Therefore, this result also aligns with the study by Warden et al. (2022), which indicates that students unfamiliar with technology tend to have low self-efficacy and vice versa. Similarly, the studies by Saeid & Eslaminejad (2017) and Turan & Koç (2018) also showed a positive correlation between self-directed learning and students' self-efficacy.

The result also indicates that online learning readiness significantly influences students' mathematics achievement. The result is similar to the study by (Joosten & Cusatis, 2020), conducted in the non-mathematics area, and Hamidy & Lam (2022), conducted in mathematics learning. Joosten & Cusatis (2020) found that the indicators of online learning readiness that influenced learning outcomes were social interaction ability, self-efficacy in online learning, and technological competence. These findings are consistent with the indicators of online learning readiness used in this study. In addition to these three indicators, online learning readiness also includes motivation and self-directed learning (Hung et al., 2010). The study by Alotaibi & Alanazi (2021) and León et al. (2015) showed that both indicators positively impact learning outcomes. Thus, the better the students are prepared for online learning, the better their mathematics achievement will be.

A significant relationship between mathematics self-efficacy and mathematics achievement was also found in this study. This finding aligns with the meta-analysis conducted by Muhtadi et al. (2022), which analyzed 40 studies and concluded that self-efficacy is essential in determining students' mathematics achievement. Empirically, this finding is also consistent with the study by Grigg et al. (2018), which found that self-efficacy is a positive predictor of students' mathematics achievement. This means that the better students' self-assessment of their abilities in facing mathematics, the better their mathematics achievement will be. This aligns with the psychological study by Verma & Bhandari (2022), which state that self-efficacy is necessary for individuals to remain resilient and strive to face challenges. Resilience and perseverance are critical factors in achieving success in learning mathematics. Therefore, mathematics self-efficacy has a positive impact on mathematics achievement.

The Sobel test results indicate that self-efficacy mediates the relationship between online learning readiness and mathematics achievement. This finding clarifies the relationship between online learning readiness, mathematics self-efficacy, and mathematics achievement. That is, online learning readiness directly influences mathematics achievement and indirectly through mathematics self-efficacy. The study by Joosten & Cusatis (2020) supports the relationship between these three variables, which states that self-efficacy is the most significant characteristic of online learning readiness influencing learning outcomes.

However, the direct effect of online learning readiness is more dominant than the indirect effect mediated by self-efficacy on mathematics achievement. This indicates that the influence of online learning readiness is more significant than that of self-efficacy. This is supported by the higher regression coefficient of online learning readiness compared to self-efficacy in relation to mathematics achievement. The more significant influence of online learning

readiness compared to mathematics self-efficacy is related to implementing online learning in the research location. In Indonesia, the sudden transition from face-to-face to online learning has made readiness a significant factor influencing mathematics achievement (Harris, 2020), although self-efficacy is also a determining factor. Therefore, the findings of this study suggest that efforts to improve mathematics achievement in the era of online learning should focus on enhancing students' readiness for online learning. Additionally, after several years of implementing online learning, further research is needed to understand better the relationship between online learning readiness, mathematics self-efficacy, and mathematics achievement.

This study was conducted on university students who may have different characteristics compared to elementary and secondary school students, especially regarding their use of technology for learning and attitudes toward mathematics. Moreover, campuses are generally more familiar with online learning than schools, which rely on face-to-face instruction before the pandemic. Additionally, this study has an imbalance between male and female participants. This may impact the accuracy of the results when relating them to the phenomenon of online learning in schools. Therefore, the study suggests implementing similar research in school settings with a balanced proportion of participants based on gender. However, these findings shed light on how students' confidence in their math abilities acts as a bridge between their readiness for online learning and their actual achievement levels. Moreover, the study highlights a pathway through which educators and institutions can enhance students' online learning experiences and subsequent performance in mathematics.

CONCLUSIONS

The results of the study indicate that both online learning readiness and mathematics self-efficacy have an impact on mathematics achievement. Online learning readiness also influences mathematics self-efficacy. Additionally, mathematics self-efficacy mediates the relationship between online learning readiness and mathematics achievement. However, the direct influence of courageous learning readiness is more dominant with 0.896 compared to the indirect influence on mathematics learning achievement with 0.525. These findings have implications for the need to provide orientation and support for students in online learning so that they are prepared to engage in mathematics learning online, and potential low mathematics self-efficacy during online learning can be reduced.

AUTHOR CONTRIBUTIONS STATEMENT

As the lead researcher, AH designed the research, collected the data (Economic and Business students), and wrote the article. IM contributed to collecting data (Elementary Education students). KTL contributed as a peer-reviewer for the substance of the article.

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