



Determinant factors of mathematics achievement in online learning during the covid-19 pandemic

Anwaril Hamidy^{1, a, *}, Kee-Fui Turner Lam^{2, b}

¹Department of Matematika Education, UIN Sultan Aji Muhammad Idris Samarinda, Indonesia

²Academic Director, Edu-Aequitas Pte. Ltd., 1 North Bridge Rd, High Street Centre, Singapore

E-mail: ^aanwarilhamidyiainsmd@gmail.com, ^bturner@edu-aequitas.com

*Corresponding Author

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ABSTRACT

Online learning has become more popular during the Covid-19 pandemic, including in mathematics. However, many educators have raised concerns whether there are critical factors determining the mathematics achievement during online learning. This study examines online learning readiness (OLR), math anxiety (MA), online platforms used in learning (Zoom Meeting and Google Classroom) and gender as determinants of mathematics achievement students in online learning. The participants in this study were 197 students of a private university in Samarinda, Indonesia. Online learning readiness and math anxiety were gathered by means of questionnaires. The questionnaires were deemed valid (> 0.500) and reliable (OLR = 0.903; MA = 0.888) based on Confirmatory Factor Analysis (CFA) and Cronbach's Alpha respectively. Other variables function as dummy based on the attributes possessed and learning experienced by the participants. The data were analyzed using standard multiple linear regression and multiple linear regression with dummy variables. The results reveal that online learning readiness, math anxiety, online learning platforms and gender had a significant effect on students' mathematics achievement in online learning. In addition, online learning platforms and gender contribute to the difference effect of online learning readiness and math anxiety to mathematics achievement. The results suggest that educators and educational institutions should consider these important aspects to optimize the advantages and effectiveness of online learning.

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INTRODUCTION

The Covid-19 pandemic, which had worsened significantly since inception, prompted the government to impose restrictions on daily activities of people, including learning activities. Online learning has become the main learning mode during the pandemic. Although blended learning has been implemented before, the rapid change in learning mode from offline to fully online may impact students' achievement, including mathematics. The limited interaction in online learning makes complex mathematics material difficult to teach without face to face (Juan et al., 2011). So, online learning has become a potential disadvantage for students in mathematics. Several studies (Anugrahana, 2021; Ariyanti & Santoso, 2020; Mahfud et al., 2021; Tambunan, 2021; Xu & Jaggars, 2014) showed that online learning has a negative impact on students' mathematics achievement, although others show no significant difference (Kemp & Grieve, 2014; Meisami, 2020). The inconsistency in these findings should be influenced by several determinants which are part of the characteristics of online learning. This study will examine several variables that are assumed to have an effect on mathematics achievement. The variables represent mental aspects, online learning characters, components of

mathematics achievement and attributes of students. So, the variance of mathematics achievement in the online learning era could be explained comprehensively.

The rapid transition from offline to online learning is allegedly not tandem with the readiness of students to adapt to it. Readiness of students' adaption relates to the level of students' readiness in online learning. The results of study by [Mailizar et al. \(2020\)](#) showed that students did not have proper readiness to adapt online learning, even before the pandemic. During online learning, it was also note that students experienced obstacles related to online learning readiness, such as technical difficulties ([Anugrahana, 2021](#)), time management difficulties and concentration ([Naidoo, 2020](#)), and also the issue of independence in learning ([Fadila et al., 2021](#)). It does not have an optimal impact on the students' learning process and thus will impact students' mathematics achievement. Therefore, online learning readiness should affect students' mathematical achievement during online learning ([Joosten & Cusatis, 2020](#)).

Apart from online learning readiness, mathematics anxiety is also expected as another major mental factor that affects students' mathematics achievement ([Süren & Kandemir, 2020](#)). Math anxiety is described as feeling nervous, afraid and under pressure when dealing with mathematics ([Ashcraft, 2002](#)). It impacts on the low frequency of students in practicing mathematics or students' incompetency in solving math problems. This condition has an impact on the low mathematics achievement of students. Several recent studies demonstrated similar results, that is math anxiety has a negative effect on mathematics ability ([Brezavšek et al., 2020](#); [Juniati & Budayasa, 2020](#); [Lee, 2021](#); [Ramirez et al., 2018](#)). However, other studies have found that there is a reciprocal relationship between math anxiety and math ability ([Carey et al., 2016](#); [Chang & Beilock, 2016](#); [Wang et al., 2020](#)). In online learning, [Faust et al. \(1996\)](#) found that anxiety was getting stronger, although it was still limited to the format of the exam, not the overall learning. Therefore, it is necessary to investigate the effect of mathematics anxiety on mathematics achievement in online learning.

The different characteristics of the subjects require different learning methods. Research by [Kemp & Grieve \(2014\)](#) showed that students prefer online learning when doing writing activities, but they prefer face-to-face when discussing. The difference in preferences relates to the quality of interactions that emerge during learning, while it is an important component in online learning ([Suliani et al., 2021](#)), and its absence is a major obstacle in learning mathematics ([Fauzy & Nurfauziah, 2021](#)).

Online learning has -at least- two learning methods, that is synchronous and asynchronous. Synchronous learning method allows educators and students to interact in real-time but ultimately is limited in time flexibility ([Shahabadi & Uplane, 2015](#)). Meanwhile, asynchronous learning makes learning not limited to space and time due to the absence of real-time interaction ([Shahabadi & Uplane, 2015](#)). In Indonesia, Zoom Meeting and Google Classroom are the most popular platforms for educators and students in online learning ([Irfan et al., 2020](#); [Ningsih, 2020](#); [Swasti, 2020](#)). These platforms represent online learning methods. Based on the advantages and disadvantages of the two online learning methods, using these platforms in mathematics lectures is expected to affect mathematics achievement. A study of [Oyarinde & Komolafe \(2020\)](#) showed that the use of Google Classroom has a positive impact on student achievement in Nigeria. Comparatively, a study of [Hamidy & Samarinda, \(2021\)](#) showed that the mathematics learning outcomes of students who use Zoom Meeting are better than Google Classroom.

Apart from mental aspects, gender has long been studied in relation to mathematics ability. For example, study of [Mahfud et al. \(2021\)](#) which shows that female students have accuracy in solving but have unstable emotions. Meanwhile, male students are more stable in emotion but do not have accuracy in solving questions. It is concluded that female and male students have different understanding abilities. However, [Devine et al. \(2012\)](#) stated that there was no significant difference between men and women in terms of mathematics ability. Meanwhile, [Xu & Jaggars \(2014\)](#) found that the gap in math skills between boys and girls is getting wider in online learning mode. Therefore, it is expected that gender affects mathematics achievement during online learning. Based on the explanation, this study will examine online learning readiness, math anxiety, online platforms used in learning (Zoom Meeting and Google Classroom), task frequency (routine and non-routine), type of task (individual and group) and gender as determinants of mathematics achievement students in online learning.

METHOD

This study is a quantitative correlational study (Cresswell, 2012) using a regression model as shown in Figure 1. The participants in this study were 197 students of UINSI Samarinda who took Mathematics courses. The demographics of the participants are presented in Table 1.

Table 1. Demographic of Participant

	N	%
Gender		
Male	45	75.68
Female	140	24.32
Platform		
Zoom Meeting	83	44.86
Google Classroom	102	55.14

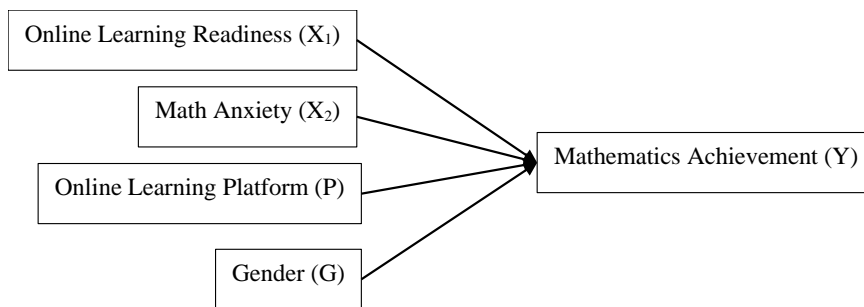


Figure 1. Research Model

Online learning readiness was measured using a questionnaire adapted from Hung et al. (2010) with 16 items. Each item uses a Likert scale. Indicators of learning readiness consist of self-efficacy towards computers/internet, learning initiative, learning control, learning motivation and self-efficacy in communicating online. The instrument was tested on 282 people. Based on the results of CFA (Confirmatory Factor Analysis), all items are valid (>0.500). Meanwhile, based on the Cronbach Alpha value, the reliability was 0.903.

Math anxiety was measured using a questionnaire adapted from May (2009) with 29 items. Each item uses a Likert scale. The indicators of math anxiety consisted of self-efficacy towards mathematics in general, anxiety about grades, anxiety about math assignments, anxiety about future mathematics, and anxiety in the classroom. The instrument was tested on 282 people. Based on the results of the CFA, an item was invalid so it was not used in data collection. Based on the Cronbach Alpha value, the reliability was 0.888. Both questionnaires were designed using a google form and completed by participants online. Participants' responses for each item of the questionnaire statement were converted into scores (Table 2) and accumulated.

Table 2. Items Score Conversion

Responses	Score	
	Positive Items	Negative Items
Never	1	5
Seldom	2	4
Occasionally	3	3
Often	4	2
Always	5	1

Other variables are dummy variables, that is online learning platforms (Google Classroom "0" and Zoom Meeting "1") and gender (male "0" and female "1") based on the attributes and learning experienced by the participants. Mathematics achievement was measured using the final grades of mathematics courses on a scale of 1-100. The final grades are a combination of participation, tasks and exams.

The data were analyzed in two method. First, standard multiple linear regression was conducted to examine the effect of online learning readiness and math anxiety on students' mathematics achievement. The classical assumptions were conducted. Second, the analysis of the influence of online learning platforms and gender on the relationship between online learning readiness and anxiety on students' mathematics learning achievement using regression analysis with the following equation as follows (Kleinbaum et al., 2008),

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 P + \beta_4 G + \beta_5 PG + \beta_6 X_1 P + \beta_7 X_2 P + \beta_8 X_1 G + \beta_9 X_2 G + \beta_{10} X_1 PG + \beta_{11} X_2 PG \quad (1)$$

The regressions for Platforms-Gender combination are as follows,

$$\text{GC - Male : } Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \quad (2)$$

$$\text{GC - Female : } Y = (\beta_0 + \beta_4) + (\beta_1 + \beta_8) X_1 + (\beta_2 + \beta_9) X_2 \quad (3)$$

$$\text{Zoom - Male : } Y = (\beta_0 + \beta_3) \beta_0 + (\beta_1 + \beta_6) X_1 + (\beta_2 + \beta_7) X_2 \quad (4)$$

$$\text{Zoom - Female : } Y = (\beta_0 + \beta_3 + \beta_4 + \beta_5) + (\beta_1 + \beta_6 + \beta_8 + \beta_{10}) X_1 + (\beta_2 + \beta_7 + \beta_9 + \beta_{11}) X_2 \quad (5)$$

Coincidence and parallel test were conducted to the regressions.

RESULT AND DISCUSSION

Result

A series of classical assumption tests were carried out before standard multiple linear regression analysis, that is normality test, heteroscedasticity test, linearity test and multicollinearity test. The results of the classical assumption test are shown in Table 3.

Table 3. Classical Assumption Tests Result

a) Normality Test		c) Deviation from Linearity		
Test Statistic (Kolmogorov-Smirnov)	0.130	Variables	F	
Asymp. Sig (2-tailed)	0.000*	X ₁ *Y	0.895	
*p<0.05		X ₂ *Y	0.733	
b) Heteroscedasticity Test		d) Multicollinearity Diagnostic		
Variables	T	Variables	Tolerance	VIF
X ₁	-3.081*	X ₁	0.814	1.228
X ₂	0.733	X ₂	0.814	1.228
*p<0.05				

Based on Table 3a), the value of sig. < α (0.05) so it concluded that the null hypothesis of normality test is rejected. Based on Table 3b), the value of sig. of X₂ is more than 0.05 so it concluded that there is no heteroscedasticity. While the value of sig. of X₁ is less than 0.05 so it concluded that the heteroscedasticity exists in the variable. Based on Table 3c), the sig value of (X₁*Y) and (X₂*Y) are more than 0.05 so it concluded that there are linear relationships between X₁ and X₂ to Y. Based on Table 3d), tolerance values of the six variables are more than 0.1 and VIF values are less than 10, so it concluded that there is no multicollinearity.

The results of standard multiple linear regression analysis are shown in Table 4.

Table 4. Standard Multiple Linear Regression Analysis Result

	B	T	F	R Square
Constant	91.508	17.921*	35.358*	0.280
X ₁	0.159	3.180*		
X ₂	-0.221	-5.654*		
*p<0.05				

Based on Table 4, the regression model is as follows,

$$\hat{Y} = 91.508 + 0.159X_1 - 0.221X_2 \quad (6)$$

The regression coefficient of the X_1 (0.159) indicates that the higher the online learning readiness score, the higher the final grade achieved by the participants. The regression coefficient of the X_2 (-0.221) indicates that the higher the math anxiety score, the lower the final grade achieved by the participants. Based on the t-test, online learning readiness and math anxiety have a significant partial effect on mathematics achievement. The result of the F test indicates that the regression model used is fitting, and all independent variables have a significant simultaneous effect on mathematics achievement. The coefficient of determination indicates that 28.0% of the mathematics achievement variance is explained by online learning readiness and math anxiety.

Next, the results of multiple regression with two dummy variables (online learning platform and gender) analysis, coincidence dan parallelism test are shown in Table 5 (P refers to online learning platform, G refers to gender).

Table 5. Multiple Linear Regression with Two Dummy Variables Analysis Result

a. Coefficients		b. Coincidence Test		c. Parallelism Test	
Model**	B	Hypothesis	F	Hypothesis	F
Constant	73.259	All regressions are coincident	13.277*	All regressions are parallel	14.564*
X1	0.279	Platform regressions are coincident	7.696*	Platform regressions are parallel	10.518*
X2	-0.155	Gender regressions are coincident	12.547*	Gender regressions are parallel	14.716*
P	36.014				
G	32.566				
P*G	-49.087				
X1*P	-0.182	*p<0.05		*p<0.05	
X2*P	-0.210				
X1*G	-0.298				
X2*G	-0.118				
X1*P*G	0.296				
X2*P*G	0.325				

** $R^2 = 0.479$

Based on Table 5a, the regression model that explain the effect of online learning platforms and gender on the relationship between online learning readiness and math anxiety to students' mathematics achievement is as follows,

$$Y = 73.259 + 0.279X_1 - 0.155X_2 + 36.014P + 32.566G - 49.087PG - 0.182X_1P - 0.210X_2P - 0.298X_1G - 0.118X_2G + 0.296X_1PG + 0.325X_2PG \quad (7)$$

And, the regressions for Platforms -Gender combination are,

$$GC - \text{Male} : Y = 73.259 + 0.279X_1 - 0.155X_2 \quad (8)$$

$$GC - \text{Female} : Y = 105.825 - 0.019X_1 - 0.273X_2 \quad (9)$$

$$\text{Zoom} - \text{Male} : Y = 109.273 + 0.097X_1 - 0.365X_2 \quad (10)$$

$$\text{Zoom} - \text{Female} : Y = 98.752 + 0.095X_1 - 0.158X_2 \quad (11)$$

Based on coincidence test (Table 5b) and parallelism test (Test 5b), all of regressions for combination are differ significantly (not coincident, not parallel). Equation 7 shows that online learning readiness has positive relationship to mathematics achievement (0.279), while math anxiety has negative as explained on previous multiple regression (-0.155). The coefficient of P (36.014) shows that participants who learn to use the Zoom Meeting platform get a higher final grade than those who use Google Classroom. The coefficient of G (32.566) shows that female participants achieved higher final grade than male participants.

The regressions for P-G combination shows that online learning platform and gender contribute to the relationship between online learning readiness and math anxiety to mathematics achievement. Male participants are more advantaged by positive relationship between online learning readiness and mathematics achievement, especially who learn to use Google Classroom. Male participants who learn to use Zoom Meeting are the most disadvantaged by negative relationship between math anxiety and mathematics achievement, while male participants who use Google Classroom are the least.

Discussion

This study aims to examine online learning readiness, math anxiety, online platforms used in learning and gender as determinants of mathematics achievement in online learning. Two questionnaires were distributed to students who took mathematics courses with various type of online learning. The final grades of these students are used as mathematics achievement data. Furthermore, the data were analyzed using standard multiple linear regression and multiple linear regression with two dummy variables.

The results showed that online learning readiness had a positive and significant effect on mathematics achievement in online learning. Learners who are better prepared for online learning will achieve better math achievement and vice versa. These results confirm the findings of [Joosten & Cusatis \(2020\)](#). So, learning readiness is one of the determinant factors of students' success in mathematics online learning during the pandemic. The learning readiness related to the preparedness of mental (such as self-regulated learning, self-efficacy, self-confidence, motivation), technical skills (such as use of computer and internet) and facilities to learn (smart phone, computer, internet, etc) ([Hung et al., 2010](#)). Thus, students' success in online learning is determined by their softs skills and hard skills, also the availability of facilities that support online learning.

The rapid transition of learning modes from offline to online during the pandemic had an impact on students. They do not have enough time to prepare for the transition. [Churiyah et.al \(2020\)](#) found that students showed low self-regulated learning during online learning even though facilities were available. The condition may be worse in schools that have difficulty providing online learning facilities. This is expected to be the cause of the low mathematics achievement in online learning during the pandemic compared to offline before the pandemic ([Atiya et al., 2021](#)). Therefore, the results of this study suggest an orientation for students about online learning ([Abdous, 2019](#)) and support them by online learning facilities ([Annur & Hermansyah, 2020](#)) so they are ready to adapt to it.

On the contrary, math anxiety had a negative and significant effect on mathematics achievement in online learning. That is, the higher the level of students' math anxiety, the lower their mathematics achievement. These results confirm that math anxiety does not only have a negative impact on offline learning ([Carey et al., 2016](#); [Chang & Beilock, 2016](#); [Wang et al., 2020](#)), but also on online learning. Thus, math anxiety is a determinant of students' mathematics achievement in the online learning era. Although math anxiety had a negative effect on mathematics achievement, the source of math anxiety in online learning could be different from offline learning mode. The source may relate to unpreparedness of students to the transition. Good preparation in online learning can overcome this anxiety. It is clear that, the prevalence of mathematics anxiety in offline and online learning shows that mathematics anxiety is an important problem in mathematics education.

The platform used in online learning also has a significant effect on mathematics achievement in online learning. It shows that the character difference of Zoom Meeting and Google Classroom has an impact on math achievement. In addition, students who use Zoom Meeting in online learning will achieve better mathematics achievements than those who use Google Classroom, as the results of study of [Hamidy & Samarinda \(2021\)](#). It shows that online learning mathematics depends on interactions between educators and students in real time ([Fauzy & Nurfauziah, 2021](#); [Suliani et al., 2021](#)). The criterion is facilitated by synchronous learning such as Zoom Meeting ([Shahabadi & Uplane, 2015](#)). Thus, educators are suggested to use a platform that emphasizes interaction in online learning mathematics such as Zoom Meeting.

Gender has a significant effect on mathematics achievement in online learning. These results confirm the findings of [Xu & Jaggars \(2014\)](#). However, the difference in mathematics achievement in online learning by gender may also be related to the character of the participants who are undergraduate students. Study of [Devine et al. \(2012\)](#) used participants at the junior high school level and found that there was no difference in mathematics ability between boys and girls. While this study used undergraduate student participants and found the opposite result. Associated with the study of [Mahfud et al. \(2021\)](#), the difference in these findings is caused by age and emotional maturity. Female undergraduate students with an older age have more stable emotions so it becomes an advantage over males in terms of mathematics ability. Therefore, future research needs to consider participant characteristics other than gender.

The results also show that platform used in online learning and gender have contribution to the relationship between online learning readiness and math anxiety. Student readiness to learn using Zoom

Meeting and Google Classroom may differ because the difference of technical skill which is part of online learning readiness (Hung et al., 2010). Zoom Meeting and Google Classroom also create different effect of math anxiety because of the teacher's presence (Rapp-McCall & Anyikwa, 2016). Several studies also confirmed there are differences online learning readiness (Devine et al., 2012; Dowker et al., 2016; Luttenberger et al., 2018) and math anxiety (Rafique et al., 2021). The results suggest teacher to select and design online learning that appropriate to students.

As previously explained, the lack of this study is that the participant segment is limited to undergraduate students. Whereas students and undergraduate students have different characters and mental development. The higher of the age, the higher of the anxiety (Dowker et al., 2016; Mata et al., 2012). On the other hand, undergraduate students' learning independence is higher than students (Kerr et al., 2006). It should cause differences in results when tested on participants at the elementary, junior or senior high school level. So, it is recommended for future study to take participants from various levels of education.

The characteristics of online learning (online learning platforms) in this study are also dichotomous variables so that they cannot provide a comprehensive description. Therefore, the next study should use multidimensional measuring tools in order to provide a more detailed phenomenon. Also, characteristics of online learning such as online learning platforms should be examined in experiment setting to validate the effect to mathematics achievement.

Statistically there are also some problems with classical assumptions that do not meet the prerequisites in this study. The assumptions of normality and heteroscedasticity for X_1 are not met. Thus, the estimator obtained is not optimal, so the research conclusions become invalid (Das & Imon, 2016). To improve the validity of the study, data transformation or additional samples can be considered.

For further research, Abdous (2019) found that online learning readiness influenced math anxiety. So, it is necessary to examine the mediating effect of math anxiety on the effect of online learning readiness on math achievement. Also, task frequency (Ayar, 2018; Gholami & Moghaddam, 2013; Lukitawati SMP Negeri, 2017) and type of task (Xu & Jaggars, 2014) in online learning should be considered.

CONCLUSION

The results show that online learning readiness, math anxiety, online learning platforms and gender had a significant effect on students' mathematics achievement in online learning. It showed that the four variables are determinants of mathematics achievement in online learning. Also, online learning platforms and gender contribute to the difference effect of online learning readiness and math anxiety to mathematics achievement.

The results of this study suggest that educators and educational institutions should consider several important aspects in order to optimize the advantages and effectiveness of online learning and reduce its shortcomings. Students need to be mentally and skillfully equipped and supported by facilities that support online learning. The potential for increasing math anxiety during online learning needs to be anticipated. The selection of an online learning platform that fits the character of the mathematical material and emphasizes interaction is very important to optimize learning.

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BRIEF PROFILE

Anwaril Hamidy was born in Samarinda on August 16th, 1992. He has finished his bachelor at Mathematics Education Department of Mulawarman University in 2014, and master at Mathematics Education Program of Yogyakarta State University in 2017. Now, he is a lecturer at UIN Sultan Aji Muhammad Idris Samarinda since 2018.