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The Significance of Guidance in Mathematics Education Courses: Before vs During the Pandemic

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Abstract

The role of lecturers as university educators in giving sufficient guidance to their students is an essential factor, especially in mathematics courses. Despite university students being viewed as autonomous learners, they still need adequacy in explanation towards mathematics concepts. During the pandemic, numerous information is accessible for students from various online sources. This condition causes educators to tend to provide less guidance. Referring to this phenomenon, is sufficient guidance still significant? This study aims to expose the significance of guidance through the tutorial class. Students as pre-service mathematics teachers of cohort 2019 from Pelita Harapan University (n = 39) were taken as participants, for they underwent tutorial classes before pandemic with sufficient guidance and during pandemic with less and minimum guidance, associated with gender and self-regulated learning (SRL) level. The instruments were a questionnaire of SRL, open questions as students' feedback, and students' holistic final scores. The quantitative study was conducted by using a three-way Anova and t-test supported by analyzing the open questions through simple coding. The results indicate that sufficient guidance brings higher learning outcomes, regardless of gender and SRL level. Further studies are opened to investigate other aspects of students' characteristics or maximizing learning method referred to guidance during online learning.

Contents

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1 Introduction

The meaningful mathematical learning process is certainly inseparable from the role of an educator. Teachers are no longer spotted as the sole source of knowledge (Wood et al., 1990) but rather as "fellow players" who build an atmosphere that students' solutions valued as mathematical ideas to provide the basis for discussion of problems (Clarke, 1997). This role indicates that the teacher acts as a tutor in the learning process. Bork & Gunnarsdottir (2001) states that the main activity of a tutor is to search for student problems and to offer assistance for the problems discovered. This treatment will certainly give focus that learning is fully active for students and also brings an interactive learning environment. In the context of mathematics learning in schools and higher education levels, several studies have been conducted related to the significance of the role of teachers in embracing all aspects of academic achievement, learning skills, and affective attitudes of the students. For instance, a study conducted by Yuniarti (2016) attempts to look for the role of mathematics teachers to enhance mathematical representation as learning skills by designing math learning activities that train students to communicate using a variety of representations. Other math abilities successfully improved by the role of the teacher are problem-solving (Cai et al., 2005; Tambychik & Meerah, 2010) and mathematical reasoning (Pengmanee, 2016; Gunawan et al., 2019) which all impact good mathematics achievements.

In the affective aspects of mathematics learning, several studies have been conducted related to the role of a teacher in dealing with learning environment issue according to mathematical beliefs (McMinn et al., 2020; Mji & Arigbabu, 2012; Soesanto & Dirgantoro, 2021), self-regulated learning (Van Alten et al., 2020; Soesanto et al., 2020), even mathematics anxiety among school students (Vukovic et al., 2013; Luttenberger et al., 2018) or university students (Prahmana et al., 2019) which affect to students' academic performance. Multifarious positive findings and conclusions obtained from these various studies, where all of them are connected to one common thread that is the presence of teachers as tutors who play a role in building interactive learning environment to overcome learning problems and increase students' learning outcomes.
Pandemic has converted the learning process order from face-to-face to autonomous-implemented design, with no exception in mathematics learning. It certainly has consequences for mathematics education, now and in the future (Bakker & Wagner, 2020) not only in the context of mathematics in schools but also in tertiary education. Students at the university level are known as autonomous learners (Soesanto et al., 2020) who need to be honed in their learning independence. Despite being required to become masters in their learning process (Zimmerman, 2015), the fact that they still need guidance in learning math cannot be ignored. Several studies report that mathematics tends to provide anxiety which makes students feel depressed, under pressure, and apprehensive when they are dealing with concepts, formulas, and problems inside (Vukovic et al., 2013; Luttenberger et al., 2018). Therefore, guidance is needed to reduce pressure and direct students to ensure a smooth learning process.

The fact of the need for guidance is not only to satisfy students' curiosity but also for the sake of their engagement through the mathematics learning process, particularly in the online learning environment (Barth, 2020). Based on a review of several studies related to online math learning, a common thing to do to improve students' engagement is the implementation of the Learning Management System (LMS) as a learning platform through gamification (Hasan et al., 2019; Rodrigues et al., 2019), learning video (Eryilmaz, 2015; Ketchum et al., 2020), and maximizing learning atmosphere through class discussions (Kosko, 2015). It is still rare to find studies that focus on synchronous activities by optimizing guidance according to the topic of the mathematics courses during this outbreak. On the other hand, students still need systematics explanation as guidance even if they can find relevant sources independently in online learning (Hidayati et al., 2019). This raises a study gap that gives space for us to attempt fulfilling the gap associated with the need for guidance in online learning due to this outbreak issue. Numerous variables have been discussed in some studies during the online learning period. One of the variables that are widely discussed is self-regulated

learning (SRL). An empirical study conducted by Yang (2020) using two-way Anova concludes that SRL supports had significant effects on students' learning performance in the online learning environment. This study proves that SRL supports are worth to be considered to improve their academic achievements. Another study conducted by Barth (2020) exposes the ways to develop SRL skills to engage the online learner, which leads us to think deeper about the importance of SRL itself. In line with this matter, a study from Carter et al. (2020) confirms strategies to enhance SRL online for remote learning. All of these studies indicate that many researchers take concern about the SRL issue towards online learning.

In addition, gender stereotype is also a factor that gets attention for some researchers to do further studies related to mathematics learning (Loewenberg Ball & Feiman-Nemser, 1988; Yang, 2020; Barth, 2020). The gender issue is often discussed related to math anxiety (Hopko, 2003), math achievements (Birenbaum & Nasser, 2006), and math learning motivation (Simanjuntak et al., 2020). Those studies give various findings and recommendations for related further studies. Meanwhile, there are still few studies that review the significance of the role of educators in the context of guidance during online learning. Hence, our study has a research question namely: to what extend about the significance of guidance during online learning. We want to compare and investigate whether the need for systematics guidance during pandemics is still needed as significantly as before pandemic or not, reviewed by their gender and SRL level.

2 Materials and Methods

Participants

The research subjects consisted of 39 pre-service mathematics teachers of cohort 2019 (15 male students and 24 female students) from Pelita Harapan University as a private university in Tangerang. The selection of participants was based on the fact that they belonged to a group of students who underwent different treatment in a tutorial class in 2 phases, namely before the pandemic (BP) (Calculus I and Geometry) in the second semester and during the pandemic (DP) (Calculus II and Linear Algebra) in the third semester. In the BP phase, students got face-to-face guidance in tutorial classes. They got optimal direction and explanation as guidance, conducted direct discussions with small groups during the learning process. In the DP phase, students were more dominant in discussions towards mathematical problems with peers through the LMS forum without direct intervention from lecturers. It could be said that students received less and minimum guidance from lecturers rather than when they studied math courses before the pandemic.

Instrument 1: SRL scales

The instruments administered were 30 items of the SRL scale that consisted of 4-Likert scales (1 = very seldom, 4 = very often). The question items were spread into 9 indicators of SRL, namely: (1) learning initiatives; (2) diagnosing learning needs; (3) setting learning goal; (4) monitoring, organizing, and controlling learning; (5) viewing adversity as a challenge; (6) finding and utilizing relevant sources; (7) choosing and establishing the right learning strategies; (8) evaluating learning processes and outcomes; and (9) self-concept (Neber et al., 2008; Kramarski & Revach, 2009; Soesanto et al., 2020). The item validity was carried out by 2 experts who had a background in Mathematics Education and empirically analyzed with confirmatory factor analysis (CFA) which yielded sufficient factor loadings as shown in Table 1. The reliability value was stated by the Alfa Cronbach coefficient (α=0.835) and categorized as high reliability.

Table 1
Factor loading on each item of SRL scales

Indicators	Item	Factor Loadings
Learning initiatives	Item 1, 2, 3	0.768, 0.577, 0.709
Diagnosing learning needs	Item 4, 5, 6	0.606, 0.533, 0.646
Setting learning goal	Item 7, 8	0.694, 0.647
Monitoring, organizing, and	Item 9, 10, 11	0.548, 0.646, 0.531

controlling learning		
Viewing adversity as a challenge	Item 12, 13, 14, 15	0.659, 0.730, 0.678, 0.698
Finding and utilizing relevant sources	Item 16, 17, 18	0.737, 0.642, 0.657
Choosing and establishing the right learning strategies	Item 19, 20, 21, 22, 23	0.678, 0.531, 0.577, 0.629, 0.597
Evaluating learning processes and outcomes	Item 24, 25, 26, 27	0.723, 0.685, 0.573, 0.556
Self-concept	Item 28, 29, 30	0.787, 0.764, 0.683

Instrument 2: students' final scores as holistic learning outcome

Supplemental instruments used were final scores obtained by students as a holistic learning outcome through tutorial classes during two semesters, which are divided into BP and DP phases. For the BP phase, the score used was the average scores of Calculus I (differential) and Geometry, while for the DP phase used the average scores of Calculus II (integral) and Linear Algebra. Final scores were obtained by combining all components of assignments, mid-exam, and final exam according to the standards set by the campus. The entire process of making exam questions was arranged based on conformity with the course learning outcome (CLO), carried out together with a team of lecturers from each subject, and validated by the Department Chair of Mathematics Education.

Instrument 3: open-ended questions as students' feedback

This instrument consisted of 4 essay questions to look deeper into students' feedback based on the implementation of tutorial class in two phases (BP and AP). The questions were compiled by a team of lecturers from the Mathematics Education study program by considering students' circumstances as learners. These questions were namely:

1. What are the advantages you have got in taking a tutorial class during the second and third semesters?
2. What things need to be fixed during the implementation of the tutorial class?
3. Is tutorial class necessary for you during online learning? Explain your argument.
4. Which circumstances do you feel necessary to have a tutorial class? Explain your argument.

Research method

The study conducted using a quantitative method supported by descriptive review to get representative and comprehensive results. Statistical test conducted using three-way Anova and t-test according to a variable of tutorial class phase (A), gender (B), and students' SRL (C). Students were divided into two groups normatively based on SRL score by considering mean and standard deviation, namely high SRL ($\geq \bar{x}+s$) and low SRL group ($\leq \bar{x}-s$) (Azwar, 2013). Table 2 showed the mapping of Anova's three-way statistics test conducted in this study. The quantitative results were reviewed more thoroughly through the description of students' feedback on open questions qualitatively. The feedback would be analyzed using simple coding to summarize important points and examined the association with the statistics obtained for reporting in this study.

Table 2
Participants' mapping according to the phase of the tutorial class, gender, and SRL level

Students' SRL (C)	Tutorial Class Phase (A)			
	Before the pandemic (A_1)		During the pandemic (A_2)	
	Male (B_1)	Female (B_2)	Male (B_1)	Female (B_2)
High (C_1)	$A_1B_1C_1$	$A_1B_2C_1$	$A_2B_1C_1$	$A_2B_2C_1$
Low (C_2)	$A_1B_1C_2$	$A_1B_2C_2$	$A_2B_1C_2$	$A_2B_2C_2$

3 Results and Discussions

Descriptive statistics, normality, and homogeneity of participants

The initial step was performed by looking at the descriptive statistics of the score on the SRL questionnaire of 39 students based on gender, namely male students (n = 15) and female students (n = 24). The score was obtained from filling the SRL questionnaire in the phase before and during the pandemic (once on each phase) and after that, the average SRL score was calculated to be divided into high SRL levels and low SRL levels.

Table 3
Descriptive statistics of participants

	n	Mean	Std. deviation	%
Students	39			
Male	15	79.47	7.643	38.46
Female	24	80.33	3.685	61.54
SRL Level				
High SRL				
Male	5			33.33
Female	8			33.33
Low SRL				
Male	6			40
Female	8			33.33

Through the description in Table 3, it was shown the average and standard deviation based on student gender, as well as a grouping based on SRL level category. The next step was to prepare for the three-way Anova test. Before performing Anova test, normality and homogeneity test should be attained as requirements of parametric statistics. Normality tests were performed on each component with terminologies referring to Table 2, and data from all components were normally distributed (Sig. > 0.05) as shown in Table 4. Furthermore, the homogeneity of variance test was conducted.

Table 4
Kolmogorov-smirnov normality test of students' final scores based on tutorial class' phases, gender, and SRL level

Phase (A)	Gender (B)	SRL (C)	Sig.	Interpretation
Before pandemic (A_1)	Male (B_1)	High (C_1)	0.360	Normal distributed
		Low (C_2)	0.811	Normal distributed
	Female (B_2)	High (C_1)	0.451	Normal distributed
		Low (C_2)	0.331	Normal distributed
During pandemic (A_2)	Male (B_1)	High (C_1)	0.958	Normal distributed
		Low (C_2)	0.959	Normal distributed
	Female (B_2)	High (C_1)	0.885	Normal distributed
		Low (C_2)	0.664	Normal distributed

As shown in Table 5, the data from all components had a homogeneous variance for Sig. = 0.107 (> 0.05).

Table 5
Levene homogeneity test of students' final scores based on tutorial class' phases, gender, and SRL level

Levene's Test of Equality of Error Variances			
F	df1	df2	Sig.
1.815	7	46	0.107

Statistical test on students' final scores using three-way anova

The next step was to perform a statistical test using a three-way Anova. The findings were displayed in Table 6. Table 6 showed that there was a significant effect on students' holistic learning outcomes by the phase of tutorial class (Sig. = 0.004 < 0.05). Referring to the data, it could be interpreted that there were significant differences in learning outcomes between the BP and DP phases.

Table 6
Three-way anova test of students' final scores based on tutorial class' phases, gender, and SRL level

Test of Between-Subjects Effects					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Phase	329.376	1	329.376	9.314	0.004
Phase*Gender	0.687	1	0.687	0.019	0.890
Phase*SRL	14.469	1	14.469	0.409	0.526
Phase*Gender*SRL	25.466	1	25.466	0.720	0.400

The difference was expressed in Table 7, where the mean for the BP phase was higher than the DP phase. It had been explained previously that the guidance of tutorial class in the BP phase was more optimal than the DP phase, and caused an impact on the mean differences obtained in both phases.

Table 7
Mean differences based on phases of guidance in tutorial class

Phase	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Before the pandemic	78.018	1.167	75.668	80.368
During the pandemic	72.979	1.167	70.629	75.329

Furthermore, related to the interaction between phase towards gender and SRL level, both gave Sig. > 0.05 consecutively 0.890 for phase and gender interactions and 0.526 for phase and SRL level interactions. This means that the interaction effect between phases on gender and SRL was not quite significant. However, we still needed to investigate more comprehensively the mean score of each case, shown in Table 8 below.

Table 8
Mean differences based on the interaction between phases towards students' gender and SRL level

Interaction between Phase and Gender					
Phase	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Before pandemic	Male	76.281	1.800	72.657	79.905
	Female	79.755	1.487	76.762	82.748
During pandemic	Male	71.013	1.800	67.388	74.637
	Female	74.946	1.487	71.954	77.939
Interaction between Phase and SRL Level					
Phase	SRL	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Before pandemic	High	82.684	1.695	79.272	86.096
	Low	73.352	1.606	70.120	76.584
During pandemic	High	76.589	1.695	73.177	80.001
	Low	69.369	1.606	66.137	72.602

For the interaction effect between phase and gender, the results in Table 8 showed that the average score for both genders experienced slight differences in comparison with BP and DP phases. For male students, the average score in the BP phase was 76.281 while in the AP phase it was 71.013. For female students, the average score in the BP phase was 79.755 while in the AP phase it was 74.946. This means that although the results were not quite significant, the BP phase provided an average score higher than the DP phase for both genders, regardless of the overall average male students are lower than female students. For interaction effect between phase and SRL level, the results in Table 8 also showed similar results that the average score for both SRL levels had slightly different in comparison with BP and DP phases. For high SRL level, the average score in the BP phase was 82.684 while in the AP phase was 76.589. For low SRL level, the average score in the BP phase was 73.352 while in the AP phase was 69.369. We could say that the BP phase provided an average score higher than the DP phase associated with the SRL level. Based on the investigation of the average score on gender and SRL, the BP phase provided a higher score than the AP phase (Weber, 2004; Eng & Julaihi, 2010). Furthermore, the three-way Anova test also examined the interaction effect between phases of tutorial class, gender, and SRL level simultaneously. The results in Table 6 showed Sig. = 0.400 > 0.05 where statistically there was no significant effect on students' holistic learning outcomes. These findings were also considered necessary to be investigated based on the average score, as shown in Table 9 below.

Table 9
Mean differences based on the interaction between phases, students' gender, and SRL level simultaneously

Phase	Gender	SRL	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Before pandemic	Male	High	80.916	2.659	75.563	86.269
		Low	71.647	2.428	66.760	76.533
	Female	High	84.452	2.102	80.220	88.685
		Low	75.058	2.102	70.825	79.290
During pandemic	Male	High	73.190	2.659	67.837	78.543
		Low	68.835	2.428	63.948	73.722
	Female	High	79.989	2.102	75.757	84.221
		Low	69.904	2.102	65.672	74.136

According to the results in Table 9, male students with high SRL levels on the BP phase obtained an average score higher than on the DP phase, as well as at the low SRL level. The same result was achieved in female students with high SRL levels in the BP phase, where the average score was higher than in the DP phase, as well as at low SRL levels (Huang et al., 2017; Teo, 2009; Sim, 2006). Therefore, statistical testing using three-way Anova showed that before the pandemic gave an average score higher than the period during the pandemic associated with gender and SRL. The statistics test results were comprehensively analyzed using participants' responses towards four open questions related to their impressions and feedback during tutorial classes before and during the pandemic. All responses from participants were read and coded to summarize important points to reinforce statistical arguments. The summary was shown in Table 10 as supplementary information of the research question.

Table 10
Coding of students' responses from an open-ended question

Questions	Key Statements	Percentage
What are the advantages you have got in taking a tutorial class during the second and third semesters?	• Giving questions with various complexities can strengthen the concepts and theories studied.	74.36%
	• Guidance from the lecturer is systematic and understandable in discussing math problems.	43.59%
	• Able to discuss with peers when encountered challenging problems.	28.21%

What things need to be fixed during the implementation of the tutorial class?	• Before the pandemic: there were no major things to be fixed. Everything was clear and conducive.
	• During pandemic:
	  • Maximizing guidance as synchronous activity during online learning.
	  • Maximizing forum discussion with peers as asynchronous activity during online learning.
		100%
		
		82.05%
		
		41.03%

Is tutorial class necessary for you during online learning? Explain your argument.	• Yes, we still need tutorial class during online learning, because:
	  • it provides problems with various complexities to be discussed.
	  • it guides us to facilitate us from difficulties in solving problems.
	  • it provides space for us to make group and peer discussions.
		100%
		
		46.15%
		
		89.74%
		
		74.36%

Which circumstances do you feel necessary to have a tutorial class? Explain your argument.	• Both conditions, but for now, we prefer to attend tutorial class during a pandemic because:
	  • it guides synchronous activity to facilitate us from difficulties in solving problems which we cannot get in a regular class.
	  • it provides space for us to make group and peers discussions which are very difficult to be held outside class hour due to time differences in some regions.
		97.44%
		
		89.74%
		
		84.61%

The findings of this study show that guidance plays a vital role in learning, especially in the time of online learning. Statistics show the average score of students' holistic learning outcomes in the "during pandemic" phase is lower than the "before pandemic" phase. The decrease in the average score is supported by the response from students as a result of less and minimum guidance on the learning process during a pandemic. From the coding results in Table 10, 82.05% of participants give inputs related to optimization of guidance in online learning. In this case, it should be emphasized that students do not receive guidance, but rather minimal guidance. Hence, most of them appreciate the provision of guidance during online learning, and at the same time, expect lecturers to give guidance as sufficient as they got before the pandemic. Guidance plays a role in creating a learning environment perceived by students as favorable to get better cognitive outcomes (Dunlop & Fraser, 2007; Anderman, 2002). In line with this, a study from McMinn et al. (2020) also states that a good learning environment will increase self-efficacy which leads to success in mathematics achievements and performances.

Other findings in the study also looked at gender cases. This study reports that the average score of female students is higher than male students, both in the BP phase and the DP phase, but not quite significant statistically (Sig. = 0.890 > 0.05). It is also supported by the participants' argument that they are equally struggling and need sufficient guidance to face online learning, regardless of their gender. Therefore, it can be concluded that there is no significant difference towards gender factor. This finding is in contrast with several empirical studies that males tend to outperform females in some mathematics areas (Battista, 1990; Fennema & Carpenter, 1981; Anokye-Poku & Ampadu, 2020). On the other hand, our finding is in line with a study conducted by Isiksal & Cakiroghi (2008) that revealed the very small effect of gender differences in mathematics achievement, which is supported by several studies (Gardunio, 2001; Mekonnen & Lebesse, 2020).

The finding related to SRL in terms of guidance statistically does not show a significant effect. However, the absence of a significant effect does not mean that there is no average difference between the SRL level and the adequacy of guidance delivered toward mathematics achievement. There are differences in average scores where the learning outcome for students with sufficient guidance (BP phase) is higher than in minimal guidance (DP phase). This occurs in each category of SRL level (high and low SRL), both male and female students. Numerous studies have investigated about SRL issue and prove that SRL gives a positive effect on mathematics performances and learning outcomes (Yang, 2020; Van Alten et al., 2020; Carter et al., 2020). A study conducted by Glogger-Frey et al. (2017) concludes that guidance is an activity that induces less extraneous load and leads to higher self-efficacy than SRL activity, which ends up with higher outcomes (Bajrami, 2015; Suweken et al., 2017; Suarsana et al., 2018). This implies that guidance becomes an important anchor and cannot be ignored. During online learning, it is essential to fulfilling the need for adequate guidance for students to help them comprehend the courses. Therefore, mathematics learning should be designed and arranged with ample guidance for getting a better understanding, performance, and achievement.

4 Conclusion

Online learning during pandemic causes students in a crisis of guidance. This study brings an insight that guidance plays important role in students' needs in math learning. It is undeniable that every student still needs guidance at this time, regardless of the number of learning resources that they can access. Further studies related to the importance of guidance also provide opportunities for other researchers to investigate more comprehensively during online or blended learning. Researchers could attempt to conduct some studies which analyze other aspects of students' characteristics referred to guidance during online learning. Researchers are also able to develop learning methods that optimize the guiding process in students' learning moment. Any reported findings may contribute and motivate educators to continue to strive for the best for the younger generation over the world.

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