

The Influence of Opportunities to Learn and Efficacy Belief Factor towards Mathematical Knowledge for Teaching

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ABSTRACT

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This study investigates the effect of learning opportunities and beliefs on the efficacy of teaching mathematics on knowledge of mathematics for teaching. Using a structured questionnaire along with paper and pencil tests adapted from the literature review, data were collected from 187 prospective primary school teachers at the Indonesian Teacher Education Institute. Data were analyzed using Smart PLS 3.0. The results of the structural equation model show that both opportunities to learn-Practicum ($\beta = 0.395, p < 0.001$) and opportunities to learn-Program ($\beta = 0.324, p < 0.001$) are positively related to mathematics. The second regression analysis is to examine the influence of teaching efficacy beliefs on mathematics. The results showed that beliefs about expectations of learning outcomes in mathematics ($\beta = 0.322, p < 0.001$) were positively related to mathematics, while personal mathematics teaching efficacy beliefs ($\beta = 0.017, p > 0.1$) were not related to mathematics. Overall, the confidence factor and opportunities to learn explain the total 54% variance in mathematics. The implications of these findings for the successful implementation of teacher education programs in Indonesia are further elaborated.



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A. INTRODUCTION

Mathematics teachers are individuals who must be responsible for carrying out an effective learning process in ensuring that each student can master the skills expected by the mathematics curriculum (Wildeman et al., 2022). The knowledge possessed by the mathematics teacher plays a role in ensuring the implementation of PdP activities effectively and it is hoped that students can develop the knowledge obtained properly and correctly (Haug & Mork, 2021). The teacher's low understanding of mathematical knowledge will have an impact on numeracy understanding and students' learning outcomes in mathematics (Syaharuddin & Mandailina, 2018). Mathematical Knowledge for Teaching (PMUP) is a concept of understanding mathematics that teachers need to teach effectively. Includes assessment, evaluation of student responses, methods of answering student questions, preparing assignments and preparing lesson plans (Lumbantoruan & Male, 2022). According to Mohsenpour et al. (2021) The PMUP concept developed is a multidimensional construction consisting of content knowledge (KK) and pedagogic content knowledge (PPK).

The Teacher Education Development Study in Mathematics (TEDS-M) conducted by the International Association for the Evaluation of Educational Achievement (IEA) in 2008 in 17 countries provided information on the knowledge of prospective elementary and junior high

school teachers during the education program. Teachers (Mangindaan et al., 2022). Indonesia is one of the countries involved in the study. A total of 524 primary school pre-service teachers and 388 junior secondary pre-service teachers who are in their final year of study were involved in the study (Lim & Yunus, 2021). The findings of the study released show that the mastery level of PMUP among prospective teachers in Indonesia is still low (Nur et al., 2022). Apart from the findings of the TEDS-M study in 2008 as explained by Blömeke et al. (2022), studies by Hainora Hamzah et al. (2022), and Zulkpli et al. (2017) also found that the level of knowledge mastery of mathematics teachers in Indonesia is low.

The low level of mastery of PMUP among teachers also affects the success of a teacher education program provided. According to Lazarides et al. (2018), The knowledge gained by prospective teachers at the end of teaching courses is one of the main indicators of the success of the teacher education program they have attended. The Ministry of National Education (KPM) annually allocates large funds to the Teacher Education Institute (IPG) in ensuring that education programs are able to produce qualified and professional mathematics teachers (Sanusi et al., 2022). If the PMUP level of teachers at the end of teaching subjects is low, this illustrates that the education programs attended by teachers are less effective in producing competent teachers and subsequently causes the return on investment made by the Ministry of Education to be of no benefit to society. To answer these problems, it is necessary to conduct a study to identify the factors that influence PMUP mastery in prospective teachers at IPG.

Personal (KEPMP) tested. In addition, Sim et al. (2022) suggested that teachers' PPK should also be linked to opportunities to learn (PUB) innovative teaching strategies. Sanusi et al. (2022) also suggested that factors such as age limits, gender and opportunities to participate in teaching skills training should be given and considered. Based on the recommendations of previous researchers, this study will examine the influence of the Belief factor on the Efficacy of Mathematics Learning (KEPM) and PUB on PMUP. Thus, based on the PMUP model by Shen et al., (2022), This research examines the conceptual model by integrating the PMUP model, Social Cognitive Theory and several sets of PUB-related variables obtained from a literature review in studying the influence of PUB factors and efficacy beliefs on PMUP among teachers in IPG.

B. METHODS

The method in this study is the PMUP model by (Liu et al., 2020). This method is appropriate in measuring the level of mastery of mathematics PK and PPK prospective teachers. PMUP theory was also used by previous researchers in measuring the level of mastery and knowledge of mathematics teachers. Among them is research by König et al. (2021) which studied the perceptions of prospective teachers related to the courses they took and their effect on PPK mathematics. In addition, Shah et al. (2020) also used the PMUP model to find out the relationship between the level of self-confidence with PK mathematics and PPK among prospective teachers. PMUP covers three categories of knowledge related to teacher PK: (1) Content Knowledge (PK), namely mathematical knowledge and skills that are not only devoted to learning mathematics; (2) Specific Content Knowledge (PKK), namely mathematical knowledge and skills that are unique and specific to learning mathematics; and (3) Horizon Content Knowledge (PKH), namely awareness of the relationship between each topic in

mathematics. In addition, PMUP also consists of three categories of KDP-related knowledge: (1) Content and Student Related Knowledge (PK Pel), namely knowledge related to students' mathematical thinking; (2) Knowledge related to Content and Teaching (PKP), namely knowledge related to teaching design, which requires interaction between understanding of mathematics and understanding related to pedagogic issues that affect student learning; and (3) Knowledge related to Content and Curriculum (KKK), namely knowledge related to teaching materials and programs.

The research integrates theories related to teacher efficacy beliefs. Social Cognitive Theory by Mozahem & Adlouni, (2021) was chosen to be used in this study. The theory was chosen because of the suitability of the variables to explain the effect of the belief factor on the effectiveness of learning mathematics on the mathematics mastery of PK and PPK prospective teachers. This is based on the research findings of Ekstam et al. (2017), De Costa & Norton, (2017), an indirect relationship between teacher efficacy beliefs and PK. Meanwhile, the findings from the research of Saltan & Arslan, (2017) found that there was a significant relationship between the level of teacher self-confidence and PK mathematics. In addition to the PMUP model and teacher efficacy beliefs, researchers will also examine the effect of the learning opportunity factor (PUB), better known as Opportunity to Learn (OTL). This factor was chosen based on the findings of previous research which found that PUB factors played a role in influencing teachers' PK and PPK mastery.

Research identifies relevant theories and establishes models. The efficacy belief variable is represented by the variables Belief in the Efficacy of Personal Mathematics Learning (KEPMP) and Belief in the Expected Results of Mathematics Education (KJHPM). PUB variables consist of opportunities to take part in teaching training (PUB-Practicum) and opportunities to take part in coherent teacher education programs (Program-PUB). The studies conducted prove that the KEPMP factor influences PMUP dominance.

H1: Belief in Personal Mathematics Teaching Ability (KEPMP) has a significant direct effect on PMUP mastery

H2: Beliefs and Expectations in Mathematics Learning Outcomes (KJHPM).

Previous studies have proven that PUB variables have an effect on teachers' PK and PPK mastery. Among them, a study by Du et al., (2017) on prospective secondary school Biological teachers found that PUB content and teaching training PUB had influenced their PPK mastery. Regression analysis showed that PUB could positively predict the KDP test scores of trainee teachers with a β value of 0.28 ($p < 0.01$) for PUB content, and a β value of 0.29 ($p < 0.01$) for teaching training PUB (practicum). This clearly shows that PUB is an important factor affecting mastery of knowledge and academic achievement of prospective teachers. Therefore, this study also examines the influence of PUB on the domination of PMUP among prospective teachers in IPG.

H3: The opportunity to take part in teaching training (PUB-Practicum) has a significant direct effect on PMUP mastery.

H4: Opportunity to participate in a coherent teacher education program (PUB Program) has a significant direct effect on PMUP

The technique of collecting data was by conducting a survey using a questionnaire on 187 prospective teachers at IPG. Before conducting the survey, the researcher first prepared a set of questionnaires that contained information in answering the research questions that had been asked. The questionnaire consists of three parts. The first contains questions related to demographic information, the second contains teacher efficacy beliefs and the third contains information related to PUB. In addition, researchers also use tests to obtain data related to PMUP levels. The cluster random sampling method was used to select respondents. The questionnaire was adapted from previous research. Because the instrument used has met the validity and reliability aspects, the content validity aspect has been fulfilled (Almanasreh et al., 2019). The establishment of a research tool to measure the PMUP variable was adapted. The items to measure PMUP for prospective teachers consist of 15 items on the math PK test and 17 items on the math PPK test. For the items testing the PK of mathematics, 4 items were from the general content knowledge domain and 11 items were from the specific content knowledge domain. As for the PPK math test questions, 13 questions consisted of knowledge related to content and students and 4 other questions from knowledge related to content and teaching. The instrument for measuring KEPM variables was adapted from (Howarth et al., 2021). The instrument consists of two dimensions, namely KEPMP and KJHPM. The instrument contains a total of 21 items, namely 13 items related to KEPMP and 8 items related to KJHPM.

Data analysis techniques using Statistical Package for the Social Sciences (SPSS) software version 23 were used for descriptive analysis. Descriptive analysis was used to obtain information in the form of average values, percentages, standard deviations, normality tests, missing data analysis and multivariate hypothesis testing. Normality testing. Smart PLS 3.0 software is used to analyze data to test the research hypothesis. Two data analysis procedures were used in this study as suggested by Chansanam & Li (2022) namely the evaluation of the measurement model and the evaluation of structural model data.

C. RESULT AND DISCUSSION

According to Larabi et al. (2019) hypothesis testing will only be conducted if the measurement model reaches the desired level of reliability and validity. To assess the reliability of each study variable, Cronbach's alpha and Composite Reliability values were used. Based on the analysis that has been carried out, it was found that Cronbach's alpha value for each construct exceeds 0.7, which is the minimum level (Mohammad & Yusoff, 2018). In addition, the researcher also referred to the Composite Reliability value to determine the reliability of each construct. Based on the analysis that has been carried out, it was found that the Composite Reliability value for all constructs is above 0.7, so it is acceptable. Construct validity testing is conducted through the assessment of Convergent Validity and Discriminant Validity aspects. A variable is considered to have convergent validity if three criteria are met, first, the factor loading value of all individual items must exceed 0.708. However, items that have factor loading values between 0.4 to 0.7 can be considered to be retained (Chen et al., 2021). Based on the findings of the study in Table 1, it was found that there are some items that have factor loading values that are less than 0.708 but those items are retained because by removing the item in question (in bold) it does not increase the AVE value and composite reliability of the construct

in question (Fong et al., 2017). Second, the composite reliability value is not less than 0.6 and thirdly the AVE value must be above 0.5 (Dash & Paul, 2021), as shown in Table 1 and Table 2.

Table 1. Analysis results of the measurement model

Construct	Item	Internal (Cronbach's alpha)	Factor loading	Composite
				Average Reliability Variance Extracted
PUB-Practicum	PUB_Prak1	0.916	0.801	0.9320.631
	PUB_Practic e2		0.830	
	PUB_Prak3		0.863	
	PUB_Prak4		0.808	
	PUB_Prak5		0.770	
	PUB_Prak6		0.780	
	PUB_Prak7		0.741	
	PUB_Prak8		0.752	
PUB-Program	PUB_Prog1	0.896	0.790	0.9210.660
	PUB_Prog2		0.730	
	PUB_Prog3		0.870	
	PUB_Prog4		0.815	
	PUB_Prog5		0.823	
	PUB_Prog6		0.840	

Table 2. Summary of research hypothesis testing

Hypothesis	<i>b</i>	t-value	Decision
(H1) KEPMP → PMUP	0.017	0.284	Nope
(H2) KJHPM → PMUP	0.322 *	5,669	Yes
(H3) PUB-Practicum → PMUP	0.395 *	6,853	Yes
(H4) PUB-Program → PMUP	0.324 *	5.179	Yes
(H5) PUB-Practicum → KEPMP	0.277 *	3,745	Yes
(H6) PUB-Program → KEPMP	0.260	3.256	Yes
(H7) PUB-Practicum → KJHPM	0.024	0.281	Nope
(H8) PUB-Program → KJHPM	0.108	1.244	Nope

Note:*p value < 0.001

While the discriminant validity is fulfilled if the Findings from the analysis of the structural model as value of the power root of AVE is greater than the attached (refer to the Appendix) show, (H1) KEPMP does correlation value of the latent variable, not have a significant direct effect on mathematical. In addition, discriminant validity can also be knowledge for teaching ($\beta = 0.017, p > 0.1$), (H2) KJHPM assessed through testing the cross loading of study items has a significant direct effect on mathematical knowledge. As shown in Table 2, the AVE root value for teaching ($\beta = 0.322, p < 0.001$), (H3) PUB-Practicum of this research variable is higher than the correlation value has a significant direct effect on mathematical knowledge of the latent

variable. Therefore, the pilot study data show for teaching ($\beta = 0.395$, $p < 0.001$), (H4) PUB-Program has that each study variable meets the required criteria. a direct effect which is significant to mathematical. A structural model explains the relationship Knowledge for teaching ($\beta = 0.325$, $p < 0.001$). In addition, the findings from the analysis that has been carried out also between one latent variable and another latent variable found that the factor (H5) PUB-Practicum has a significant. Structural model analysis is not only direct effect on KEPMP ($\beta = 0.277$, $p < 0.001$) and (H6) aimed at testing hypotheses, but it also involves testing the PUB-Program also has a significant direct effect on strength of the relationship between the dependent variable KEPMP ($\beta = 0.260$, $p < 0.001$). While the influence of and the independent variable. In addition, the structural factors (H7) PUB-Practicum and (H8) PUB-Program was model also displays the amount of variance (R^2) explained found to have no significant direct effect on KJHPM ($\beta =$ by the independent variable over the dependent variable 0.024 , $p > 0.1$ and $\beta = 0.10$, $p > 0.1$). Overall, the model and the Entire model. Table 1 and Table 2 show the explains the value of the variant against.

This study was conducted to examine the factors that influence PMUP among pre-service teachers in Indonesia. This study has tested the influence of KEPM and PUB factors on PMUP and the influence of PUB factors on teachers' KEPM. Based on the analysis conducted, it was found that the KJHPM factor has a significant relationship with PMUP ($\beta = 0.322$, $p < 0.001$). This finding confirms that pre-service teachers who have a high positive KJHPM will also master the PMUP learned while attending the teacher education program at IPG. This finding confirms that pre-service teachers who have a high KEPM will also master the PMUP learned while attending the teacher education program at IPG.

There are several possibilities that cause KJHPM factors to play a role in influencing the level of pre-service teachers' mastery of PMUP. Among them is because they believe that effective teaching methods can affect students' mathematics achievement (Hwang et al., 2021). Pre-service teachers' beliefs regarding the importance of effective teaching may have influenced their PMUP to some extent. This is because according to Alam (2020), effective teaching activities can influence student achievement. For example, if a teacher believes that effective teaching can contribute to students' mathematics achievement, then this will encourage them to study PMUP to ensure that they can teach more effectively in the future. Findings from testing this hypothesis are supported by some findings from previous studies. Among the findings from the study who found that KJHPM is one of the factors that influence the PMUP of pre-service teachers in the United States. However, it is different for the findings of the study showing that the KJHPM factor does not affect the teacher's PMUP. As the party responsible for training pre-service teachers who will serve as primary school mathematics teachers, IPGM should take some necessary steps to ensure that the level of KJHPM can be improved? The increase in the level of KJHPM is important because it is one of the factors that contribute to the increase in the mastery of PMUP among pre-service teachers in IPG. Apart from the PUB factor obtained while following the teacher education program at IPG, other factors which identified to influence their KJHPM is emotional intelligence (Dåderman & Kajonius, 2022). Therefore, it is suggested that the IPGM can design a mathematics education curriculum that can stimulate the emotional intelligence of pre-service teachers in the future.

In addition, according to Salas-Rodríguez & Lara (2022) and Hennessy et al. (2022) on the

other hand, the level of belief in teacher efficacy can be increased through professional development programs. While following the teacher education program at IPG, the trainee teachers were exposed to various courses to ensure they are able to become competent teachers in the future. Therefore, the IPGM is suggested to redouble its efforts to provide more robust professional development courses and programs to ensure that the level of confidence in the efficacy of pre-service teachers can be increased and indirectly contribute to an increase in their mastery of PMUP. Findings from the hypothesis testing that has been carried out show that the PUB factor has the strongest positive relationship with the PMUP of pre-service teachers in IPG. More information about the results of the analysis carried out has been displayed in Table 3. This finding confirms that pre-service teachers who obtain a high positive PUB will also master the PMUP learned while attending the teacher education program at IPG. Based on the analysis that has been carried out, it is also found that the PUB factor among pre-service teachers is explained by the opportunity factor to undergo teaching training more dominantly ($\beta = 0.395$, $p < 0.001$) than the opportunity factor to follow a coherent teacher education program ($\beta = 0.325$, $p < 0.001$).

The balance between theory and practice is important to produce quality prospective teachers in the future. Every pre-service teacher at IPG has been given sufficient opportunities to deepen knowledge either in terms of theory or practice. The curriculum designed by the IPGM covers all aspects to ensure that the potential teachers produced are able to compete and can successfully educate students. In addition, the opportunity to undergo teaching training (practicum) for two phases, which is about three months for each phase with the guidance of experienced lecturers and mentors, also contributed to some extent to the perception of pre-service teachers related to PUB obtained during the education program teacher at IPG. This is because the period of undergoing sufficient teaching training can affect the level of mastery of PMUP of pre-service teachers. This finding confirms that pre-service teachers who obtaining a high positive PUB will also master the PMUP learned while following the teacher education program at IPG.

This finding is supported by some findings from previous studies. A study by (et al., 2020) found that PUB is one of the factors that influence the PMUP of pre-service teachers. A study by van Steen & Wilson (2020) also found that PUB factors have influenced teachers' knowledge. In addition, a study conducted by Mintz et al. (2020) on two pre-service teachers in Australia also found that practicum experience is an important factor that can help them form mathematical PK. Findings from a study by Ford & Minshall (2019) showed that there is a significant relationship between PUB obtained by in-service teachers while following a teacher education program and PMUP. The study was conducted on pre-service teachers in several countries using data from the IEA. Meanwhile, a study by Meroño et al. (2021) conducted on teachers in five countries using TEDS-M data also found that the PUB factor affects the knowledge mastery of a pre-service teacher. Findings from other studies also support the findings of this study, including studies by (Blömeke et al., 2017) and (Höhn et al., 2017). Findings from a study conducted by Perna & Wiedmer (2020) showed that there is a significant relationship between PUB and PMUP of pre-service teachers. The study was conducted on pre-service in Germany. Meanwhile, a study by Höhn et al. (2017) also conducted on 444 Germans, also found that the PUB factor affects pre-service teachers' mastery of knowledge. A recent study conducted by

Livy & Downton (2018) for teachers in Australia also found that PUB factors affect teachers' PMUP. In addition, a study by Guo et al. (2020) also shows that there is a significant relationship between PUB and PMUP.

IPGM's role as an institution responsible for producing competent mathematics teachers, is a sign from the Ministry of Education and Culture to provide sufficient allocations to ensure that the widest possible PUB can be enjoyed by pre-service teachers. Apart from providing opportunities to undergo practicum and coherent teacher education programs, pre-service teachers should also be given opportunities to learn knowledge related to pedagogy more effectively. The opportunity factor to learn knowledge related to general pedagogy and mathematics pedagogy can influence the level of knowledge mastery of pre-service teachers. The delivery of knowledge related to pedagogy to pre-service teachers is directly related to the structure of the curriculum and the quality of lecturers. Therefore, in order to guarantee the delivery of knowledge related to pedagogy more effectively, it is suggested that the IPGM always update the mathematics education curriculum and at the same time also carry out continuous efforts to improve the competence of mathematics lecturers in the delivery of knowledge related to pedagogy (mathematics education). Findings from testing H5 and H6 show that the PUB factor has a positive relationship with KEPM. More information from the analysis conducted has been displayed in Table 3. This finding confirms that pre-service teachers who obtain a high positive PUB will also influence their KEPM. This situation may occur due to the experience that pre-service teachers go through while following the teacher education program has influenced their self-efficacy beliefs. For example, the experience of going through school-based experiential programs, micro-teaching exercises and practicum experiences have led them to believe that student learning is influenced by effective teaching (KJHPM). In addition, the experiences they have had while following the teacher education program are also likely to have caused them to feel more confident about their ability to teach (KEPMP). This finding is supported by some findings from previous studies. Among the findings from the study by Suprpto (2020) who found that PUB is one of the factors that influence the KEPM of pre-service teachers. Findings from other studies also support the findings of this study, including a study by Philippou et al. (2021) who also found that the opportunity factor to follow a coherent teacher education program affects teachers' KEPM. A recent study conducted by Berger et al. (2018) on 154 vocational teachers also found that the factor of teaching experience (PUB-Practicum) affects teachers' efficacy beliefs.

Research related to teacher knowledge is an ongoing and developing field of study. Based on the critical analysis that has been carried out, it was found throughout the year 2017 until June 2018, there are already almost 30 studies related to teacher knowledge published in selected journals. This clearly proves that research related to teacher knowledge is important and is the focus of researchers around the world. According to Ren et al. (2018), more research is needed in the future to explain how mathematics knowledge and teachers' beliefs are interrelated with each other. This study only focuses on the factors that affect PMUP among pre-service teachers only. Therefore, in the future it is suggested that the scope of the study be expanded to in-service mathematics teachers and mathematics lecturers at IPG and Public Higher Education Institutions. In addition, it is also suggested in the future that this study be extended to pre-service teachers in the field of early childhood education and rehabilitation.

This is because both fields also require mastery of PMUP in implementing their teaching. In addition, from the point of view of model testing, it is suggested in the future to test factors such as socio-economic status and involvement in teaching and research (teaching and research) as variables that affect PMUP. This is because according to Wen et al. (2019), socio-economic status factors also influence pre-service teachers' mastery of PK and PPK. Meanwhile, a study by Mu et al. (2018) found that the factor of involvement in teaching and research also affects teachers' knowledge. Therefore, in the future it is suggested that these two factors be included and tested in the model of factors that affect pre-service teachers' PMUP.

D. CONCLUSION AND SUGGESTIONS

The findings from this study reveal that the main factor influencing PMUP for prospective teachers is PUB. The provision of opportunities to participate in coherent teacher education programs as well as opportunities to attend teaching training by the IPGs had a positive effect on their PMUP. This factor has implications for students' understanding and way of thinking in understanding the material being studied. According to Barnard-Brak et al. (2018) besides being able to increase PMUP, PUB factors can also increase the mathematics learning achievement of prospective teachers. Apart from the PUB factor, the KJHPM factor was also found to influence the PMUP of prospective teachers. Overall it is known that the resulting model of the factors that influence PMUP for prospective teachers is valid. Based on the analysis conducted, it is known that the two factors, namely KEPM and PUB, have a contribution of 54% to the PMUP variant. That is, overall this model has moderate predictive power. Thus it is necessary to carry out further research in the future by considering the factors that have been suggested to increase the predictive power of this model. Therefore, in the future it is recommended that IPG open more PUB opportunities for prospective teachers to assist them in improving their mastery of PMUP. The research suggests further research to develop these findings and combine them in the world of digital technology in the learning process.

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