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Research articles

Evaluating partial and simultaneous effects of logical-mathematical, visual-spatial, and intrapersonal intelligence on prospective primary teachers' problem-solving

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Abstrak Pemecahan masalah merupakan jantung pembelajaran matematika yang bisa dipengaruhi oleh faktor kecerdasan. Jenis kecerdasan yang berpotensi memiliki pengaruh adalah logis-matematis, spasial-visual, dan intrapersonal. Penelitian kuantitatif *ex post facto* ini bertujuan untuk menguji pengaruh dari ketiga kecerdasan tersebut terhadap kemampuan pemecahan masalah matematis secara parsial maupun simultan. Sebanyak 207 mahasiswa calon guru sebagai sampel penelitian dipilih melalui *proportional stratified random sampling* menggunakan rumus Slovin. Data dikumpulkan melalui tes dan kuesioner yang sudah diuji validitas isi dan konstruk serta reliabilitas konstruk dan komposit. Uji prasyarat data meliputi uji normalitas, linearitas, multikolinearitas, dan heteroskedastisitas. Uji hipotesis dilakukan melalui uji regresi berganda. Hasil penelitian menunjukkan bahwa kecerdasan logis-matematis, spasial-visual, dan intrapersonal secara simultan berpengaruh signifikan terhadap kemampuan pemecahan masalah matematis dengan besar pengaruh 30,3%. Secara parsial, hanya kecerdasan intrapersonal yang tidak memiliki pengaruh signifikan terhadap kemampuan pemecahan masalah matematis.

Kata kunci *Pemecahan masalah matematis, Logis-matematis, Visual-spasial, Intrapersonal, Kecerdasan*

Abstract Problem-solving is the heart of mathematics learning that can be influenced by intelligence. Logical-mathematical, visual-spatial, and intrapersonal intelligence have possible effects on problem-solving. This ex post facto quantitative research aims to evaluate the effect of the three intelligence on the ability of prospective primary teachers (PPTs) to solve mathematical problems partially and simultaneously. The research sample (n=207) was selected through proportional stratified random sampling using the Slovin formula. Data were collected through a test and questionnaire that had been tested for content and construct validity as well as construct and composite reliability. Data prerequisite tests include tests for normality, linearity, multicollinearity, and heteroscedasticity. Hypothesis testing is done through a multiple regression test. The results show that logical-mathematical, visual-spatial, and intrapersonal intelligence simultaneously have a significant effect on PPTs' mathematical problem-solving, with a large effect of 30.3%. Partially, intrapersonal intelligence does not have a significant effect on problem-solving ability.

Keywords *Mathematical problem-solving, Logical-mathematical, Visual-spatial, Intrapersonal, Intelligence*

Introduction

Mathematical problem-solving is one of the higher-order thinking skills in mathematics learning. Wahidin and Sugiman (2014) reveal that many countries, including Indonesia, include

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problem-solving as the heart of mathematics learning. The National Council of Teachers of Mathematics (2000) also suggests that problem-solving is one of the five basic strands of mathematics teaching and learning and can be used by students to solve problems in daily life. Thus, students are required to be able to develop their problem-solving skills. Teachers have a critical role in developing students' mathematical problem-solving. This is because the quality of teachers is the key to the quality of education (Jatirahayu, 2013). Considering the magnitude of the tasks that will be handled in the future, undergraduate students who take (primary) teacher education must also prepare their problem-solving competencies.

Developing students’ problem-solving can be done by situating the factors that influence it. One of the factors is intelligence (Janawi, 2013; Novitasari et al., 2015). The theory of intelligence that has proximity to student achievement, including mathematics, is the multiple intelligence (Abdi et al., 2013; Ahvan et al., 2016; Perez et al., 2014; Uzunöz & Akbaş, 2011). It was Gardner and Hatch (1989) who introduced the term multiple intelligences and also defined intelligence as the capacity to solve problems and as a valuable product in one or more cultural settings. This intelligence theory categorizes nine types of intelligence: linguistic, logical-mathematical, visual-spatial, kinesthetic, musical, interpersonal, intrapersonal, naturalist, and existential (Pehlivan & Durgut, 2017). Because of their diverse characteristics, each type of intelligence has the potential to affect differently on mathematical problem-solving ability (Karamikabir, 2012; Karatas et al., 2017).

Several types of intelligence have been studied, and the results show an influence on mathematical problem-solving. One type of intelligence that affects a person's mathematical ability is logical-mathematical (Azinar et al., 2020). Logical-mathematical has a positive and meaningful effect on overall academic performance, especially in the area of mathematics (Etchepare et al., 2011). This intelligence has proven to affect basic mathematical abilities, including the problem-solving ability (Hartanti, 2019). Fatimah (2020) also proved that students with low logical-mathematical have low abilities in solving mathematical problems and vice versa. This type of intelligence is related to the ability to process numbers, so it is needed at the stage of carrying out problem-solving plans. Thus, the level of optimization of logical-mathematical intelligence can determine the level of one's mathematical solving.

Another intelligence that has been proven by many previous studies is visual-spatial. Šafranj and Zivlak (2018) point out that visual-spatial intelligence is the ability to visualize space and objects in mind. The training that aims to improve visual-spatial intelligence can also increase mathematical abilities (Adams et al., 2022; Sorby & Veurink, 2019). Novitasari et al. (2015) assert that visual-spatial intelligence helps students visualize and present the right visual ideas. Previous research has consistently proven that visual-spatial is a primary predictor of geometry (Battista et al., 1982; Delgado & Prieto, 2004), and learning that is integrated with spatial development can be transferred to performance on completion of geometry tasks (Hawes et al., 2017; Lowrie et al., 2018). Thus, visual-spatial intelligence is one aspect that helps students solve mathematical problems, especially in providing accurate images of geometric shapes and transforming their perceptions.

Furthermore, intrapersonal intelligence is another type of intelligence that several previous studies have investigated. It plays an important role in solving mathematical problems (Mulbar et al., 2019). Intrapersonal intelligence relates to the ability to recognize oneself, and this ability is essential in initiating and interpreting a problem (Sener & Çokçaliskan, 2018). In addition, intelligence characterized by sensitivity to one's feelings can also help create a comfortable learning atmosphere so that mathematical abilities will be supported. And in any condition, including solving mathematical problems, this intelligence will continue to be needed to motivate when facing difficulties, foster optimism, and provide enthusiasm to continue learning (Abdi et al., 2020; Guseh et al., 2015; Zhoc et al., 2018).

Based on the explications above, the types of intelligence that show potential as predictors of mathematical problem-solving ability are logical-mathematical, spatial-visual, and intrapersonal intelligence. Someone possibly has a combination of these three bits of intelligence, thus allowing the effect of the combination of all three simultaneously. Hertanti and Wutsqa (2019) emphasize that educators must be able to identify the dominant type of intelligence and the unique combination of several bits of intelligence to be able to make good learning plans. Several previous studies have simultaneously examined the combination of logical-mathematical and spatial-visual intelligence (e.g., Akhmad, 2019; Aziz et al., 2020; Pratiwi & Ekawati, 2019), but only some studies have considered the influence of intrapersonal intelligence as well (Hairil, 2020; Supardi, 2013), even that is not specific to problem-solving ability and the research sample is not PPT. Thus, research involving these three bits of intelligence, including the current research, can contribute as a reference to the predictor of mathematical problem-solving ability as well as prove whether the ability to understand oneself also has a contribution to this ability.

Overall, the hypotheses proposed in this study are (1) logical-mathematical intelligence partially has a significant effect on the PPTs' mathematical problem-solving abilities, (2) visual-spatial intelligence partially has a significant influence on students' mathematical problem-solving abilities, (3) intrapersonal intelligence partially has a significant effect on students' mathematical problem-solving abilities, (4) logical-mathematical, visual-spatial, and intrapersonal intelligence simultaneously has a significant influence on students' mathematical problem-solving abilities. Therefore, this study aims to determine whether there is an influence between the three bits of intelligence either partially or simultaneously on the prospective teachers' mathematical problem-solving ability.

Logical-mathematical

Intelligence is one of the factors that affect mathematical problem-solving abilities (Janawi, 2013; Novitasari et al., 2015). The results of some previous research prove that logical-mathematical affects mathematical problem-solving abilities (Azinar et al., 2020; Etchepare et al., 2011; Irawan et al., 2016). This intelligence has an influence on problem-solving because of its characteristics, namely (1) understanding patterns and relationships, (2) classifying and comparing, (3) making hypotheses, (4) performing mathematical calculations, and (5) inductive and deductive thinking (Arum et al., 2018; Fatimah et al., 2020; Willis & Johnson, 2001). These abilities are the competencies needed in all stages of problem-solving.

Understanding patterns and relationships, as well as the ability to classify and compare, play a major role in understanding problems (Arum et al., 2018). In the research of Islami et al. (2018), students with this intelligence tend to easily write down what is known, sought, and related information needed at the stage of understanding the problem. And then, making hypotheses and inductive and deductive thinking allows a person to reason and relate the information contained in mathematical problems so that they can determine the right methods to solve the problems (Irawan et al., 2016). And then performing mathematical calculations is vital in the implementation of problem-solving plans that have been prepared (Karamikabir, 2012).

Thus, the various indicators contained in logical-mathematical intelligence are abilities needed in mathematical problem-solving activities.

Visual-spatial

The form of mathematical problems is quite diverse, one of which is a visual problem equipped with geometric images. The ability to understand visual problems requires proper image visualization skills. Visual-spatial intelligence helps students visualize and present the right visual ideas (Novitasari et al., 2015). This is because someone with visual-spatial skills has the capacity to accurately visualize geometric shapes and transform perceptions (Pehlivan & Durgut, 2017). Prior studies have shown this intelligence relates to problem-solving in mathematics (Adams et al., 2022; Battista et al., 1982; Delgado & Prieto, 2004; Sorby & Veurink, 2019). Research by the Teachers Union in Australia also found that students' difficulties in solving geometry problems were caused by a high level of abstraction of geometric objects and a lack of ability to visualize abstract objects (Owens & Reddacliff, 2002). The lack of ability to visualize objects is an indication of low visual-spatial intelligence (Pehlivan & Durgut, 2017). This shows that low visual-spatial intelligence can affect a student's low mathematical problem-solving ability.

Visual-spatial intelligence has several indicators, namely (1) spatial perception, (2) spatial visualization, (3) mental rotation, (4) spatial relations, and (5) spatial orientation (Hanifah et al., 2018; Maier, 1998; Nasution et al., 2019). These indicators are very much needed in solving problems, especially in geometry and measurement topics (Adams et al., 2022; Mamolo et al., 2015). Some previous studies specifically used visual-spatial as the main predictor in geometry (Battista et al., 1982; Delgado & Prieto, 2004). In addition, this intelligence has also been proven to be a predictor in algebra (Kyttälä & Lehto, 2008). Newcombe et al. (2019) explain that geometry problems involve mental rotation indicators or reasoning about transformations that require the ability to imagine rotating objects and visualize changes, while algebra involves more mental operations that require remembering the location of numbers and variables, relevant operations, and complete mental arithmetic.

Intrapersonal

Solving mathematical problems requires higher-order thinking skills. A student will be prone to experiencing mathematical anxiety and a decline in motivation when facing mathematical difficulties (Hidayat & Ayudia, 2019). Mathematical problem-solving ability can be optimal when the student’s emotional condition can be controlled properly. The ability to understand both feelings and moods and also manage them to avoid distractions is an indicator of intrapersonal intelligence (Paradita et al., 2019). Intrapersonal intelligence is the ability to understand ourselves, including our strengths and weaknesses (Pehlivan & Durgut, 2017). A person with intrapersonal intelligence also has skills, such as reminding oneself to do something, placing oneself as a learner, and knowing how to handle feelings when facing learning challenges (Vongkrahchang & Chinwonno, 2016). So, when students with high intrapersonal intelligence are faced with mathematical problems, they will be likely proficient in choosing the most suitable strategy for solving these mathematical problems.

Intrapersonal intelligence has several indicators, which include (1) knowing ourselves, (2) knowing what we want, and (3) knowing what is noteworthy in ourselves (Azid & Yaacob, 2016; Behjat, 2012; Paradita et al., 2019). Having those three indicators can help someone to make judgments, build mental readiness, and make decisions (Perez & Ruz, 2014). Rampullo et al. (2015) also suggest that someone who knows what they want and what is noteworthy in themselves is competent in predicting and setting personal goals. Thus, intrapersonal intelligence can build self-understanding, self-motivation, and self-emotional control so that mathematical problem-solving abilities can be optimal (Abdi et al., 2020; Guseh et al., 2015; Zhoc et al., 2018). Research by Okwudubaet al. (2021) shows that students with good intrapersonal intelligence have good self-directed learning abilities so that academic abilities, including mathematical problem-solving, can be developed.

Methods

Research design and samples

This study applies a quantitative approach with ex post facto design. It uses existing data or data collected without manipulating the research sample (Simon & Goes, 2013). One form of ex post facto used in this study aims to find the effect of one variable on other variables. There are four variables, namely three independent variables and one dependent variable. The independent variables in this study were logical-mathematical intelligence (X_1), visual-spatial intelligence (X_2), and intrapersonal intelligence (X_3). At the same time, the dependent variable is the student's mathematical problem-solving ability (Y). The form of research design based on the explanation is as follows.

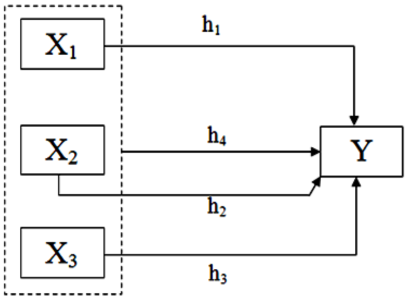

Figure 1. Research design

X_1 (Logical-mathematical intelligence); **X_2** (Visual-spatial intelligence); **X_3** (Intrapersonal intelligence); **Y** (Mathematical problem-solving ability); **h_1** (The partial effect of logical-mathematical intelligence on mathematical problem-solving ability); **h_2** (The partial effect of visual-spatial intelligence on mathematical problem-solving ability); **h_3** (The partial effect of intrapersonal intelligence on mathematical problem-solving ability); **h_4** (The simultaneous effect of logical-mathematical intelligence, visual-spatial intelligence, and intrapersonal intelligence on mathematical problem-solving ability)

The research population was 429 PPTs enrolled in Primary School Teacher Education program. Using the Slovin formula (Guilford & Frucher, 1973), the number of research samples selected using proportionate stratified random sampling was 207. The strata referred to in this study include four strata, namely PPTs in the 2nd semester, 4th semester, 6th semester, and 8th semester. Sequentially, each sample of all stratum that has been randomly selected was 55 PPTs in the 2nd semester, 53 PPTs in the 4th semester, 45 PPTs in the 6th semester, and 54 PPTs in the 8th semester.

Instruments and data collections

This study used a test and a questionnaire for data collection. The test is intended to obtain data on logical-mathematical intelligence (X_1), visual-spatial intelligence (X_2), and mathematical problem-solving ability (Y). The type of test used in collecting data on X_1 and X_2 is an intelligence test. And the type of test to measure Y is the achievement test. While the questionnaire is used to measure X_3, and it has two types of statements, namely favorable (positive) and unfavorable (negative) statements.

The instruments have proceeded through the validity and reliability test phase. The validity test carried out includes content and construct validity. The content validity involves three experts in the field of mathematics and three experts in the field of psychology or counseling. The experts in the field of mathematics validate the instruments of X_1 and Y, while the psychologists validate the instruments of X_2 and X_3. The expert judgments were analyzed based on the Content Validity Index (CVI) using the Aiken index (Retnawati, 2016). The results that meet the criteria (V value > 0.8) in each variable include 20 items of X_1 instrument, 20 items of X_2 instrument, 33 items of X_3 instrument, and 12 items of Y instrument.

Furthermore, all instruments went through a trial involving 108 participants who were also PPTs with the same character, but they were excluded from the research sample. With the help of the LISREL 8.80 program, the test results of the instrument were analyzed for construct validity and construct and composite reliability. The construct validity followed the Structural Equation Modeling (SEM) with a measurement model examined through Confirmatory Factor Analysis (CFA) (Marsh et al., 2014). The criteria for the instrument to be valid as constructs are having a loading factor (λ) value > 0.5, average variance extracted (AVE) > 0.5, and AVE root value > 0.7 (Jogiyanto, 2011). Meanwhile, the calculation of construct reliability through the value of Construct Reliability (CR) > 0.7 and the composite reliability through the Omega (ω) coefficient with criteria ω value > 0.7 (Margono, 2013). As a result, the number of items declared valid and reliable is 17 items of X_1 instrument, 16 items of X_2 instrument, 19 items of X_3 instrument, and 5 items of Y instrument. Table 1 shows the excerpt of the results of the CFA for the first indicator of the X_1.

Table 1. Loading factor of a sample indicator of the logical-mathematical items

Logical-mathematical										
Indicator	**Item**	**Loading Factor (λ)**					**AVE**	**AVE Root**	**CR**	**ω**
		1	2	3	4	5				
A*	A1	0.69					0.614	0.784	0.742	0.75
	A2	0.68								
	A3	0.59								
	A4	0.56								
	A5	0.55								

**Understanding pattern and relation*

The final instruments of each variable have indicators and descriptions that are shown in Table 2. The X_1 instrument consists of 17 multiple choice questions: understanding patterns and relationships (5 items), classifying and comparing (3 items), making hypotheses (2 items), performing mathematical calculations (4 items), and inductive and deductive thinking (3 items) (Arum et al., 2018; Fatimah et al., 2020; Willis & Johnson, 2001). The X_2 instrument contains

16 multiple choice questions, which are divided into 4 questions of spatial perception, 6 questions of spatial visualization, 2 questions of mental rotation, 2 questions of spatial relations, and 2 questions of spatial orientation (Hanifah et al., 2018; Maier, 1998; Nasution et al., 2019). The X_3 instrument is made up of 19 statements: knowing themselves (11 items), knowing what they want (4 items), and knowing what is noteworthy in themselves (4 items) (Azid & Yaacob, 2016; Behjat, 2012; Paradita et al., 2019). And finally, the Y instrument consists of 5 essay tasks which include indicators of understanding the problem, preparing a settlement plan, implementing a settlement plan, and looking back at the process and answers (Aziz & Akgül, 2020; Kusdinar, 2016; Polya, 1973).

Table 2. **Indicators** of the research instruments

Variables	Indicators	Descriptions
X_1	1. Ability to understand patterns and relationships	1.1 Determining the most logical and consistent sequence of sequences 1.2 Determining solutions from patterns in solving problems
	2. Ability to classify and compare	2.1 Grouping a number according to the type of the number 2.2 Finding the solution to the comparison case
	3. Ability to make hypotheses	3.1 Making a conjectured answer, then do the proof of the allegation
	4. Ability to perform mathematical calculations	4.1 Determining the results of mathematical arithmetic operations 4.2 Solving algebraic calculations
	5. Inductive and deductive thinking skills	5.1 Making conclusions on mathematical logic material
X_2	1. Spatial perception	1.1 Knowing the parts of an object in a vertical or horizontal position
	2. Spatial visualization	2.1 Visualizing a configuration in which there is movement or displacement among parts of the configuration
	3. Mental rotation	3.1 Knowing the change of flat shape or building space based on the direction of rotation
	4. Spatial relations	4.1 Comprehending the spatial configuration of objects or parts of an object and their relation to each other
	5. Spatial orientation	5.1 Orientating an object from a different point of view
X_3	1. Knowing ourself	1.1 Awareness to recognize one's feelings 1.2 Skills to express thoughts, feelings, opinions, and beliefs 1.3 High self-assessment
	2. Knowing what you want	2.1 Self-knowledge of personal goals and purposes. 2.2 Maximize your own potential
	3. Knowing what is important	3.1 Self-knowledge of personal values 3.2 Have an independent attitude
Y	1. Understanding the problem	1.1 Identifying known elements 1.2 Identifying the element in question 1.3 Checking the adequacy of the information needed to solve the problem

Variables	Indicators	Descriptions
	2. Develop a solution plan	2.1 Restating the problem into an appropriate mathematical model 2.2 Using the correct formula
	3. Implement the plan	3.1 Doing calculations correctly 3.2 Writing answers thoroughly, systematically, and correctly
	4. Looking back at the procedures and answers	4.1 Conducting a structured review of solutions that are suitable for the problem under review 4.2 Substituting the solution obtained into the original formula/using other methods correctly

Data analysis

Data analysis was carried out quantitatively through descriptive statistics and inferential statistics with the help of the SPSS 22 program. The classical assumption test used as a prerequisite test was through 4 stages; normality, linearity, multicollinearity, and heteroscedasticity tests (Alita et al., 2021; Daoud, 2017; Klein et al., 2016). The hypothesis testing used a multiple linear regression test. The *t* value in multiple linear regression is used to determine whether there is a significant effect of the independent variable partially on the dependent variable so that it can be used to test the first to third hypotheses (Mardiatmoko, 2019). While the F test is used to determine whether there is a significant effect of all independent variables simultaneously on the dependent variable so that it is used to test the fourth hypothesis. In addition, data analysis was also held to find the value of the determinant coefficient (R^2) and also the effective and relative contribution.

Findings

The results of descriptive statistics (Table 3) from the independent variable data and the dependent variable were collected and analyzed for the minimum, maximum, sum, mean, standard deviation, and variance values.

Table 3. Descriptive statistics of the research data

Variable	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
X_1	64.00	100.00	17349.00	83.8116	8.53367	72.824
X_2	35.00	100.00	14888.00	71.9227	16.08092	258.596
X_3	51.58	97.89	14372.65	69.4331	8.28869	68.702
Y	64.00	100.00	17723.00	85.6184	7.24229	52.451

Furthermore, prerequisite tests were carried out in the form of the normality test, linearity test, multicollinearity test, and heteroscedasticity test. The results of the classical assumption test (Table 4) show that the data has passed the prerequisite tests. The dependent and independent variables are normally distributed, so it has an impact on the test results that also have normally distributed data, or the regression model is close to normal (Alita et al., 2021). In addition, the data also passed the linearity test, where the results had a direct calculation impact and easy interpretation (Baek et al., 2015). The research data did not experience heteroscedasticity, meaning that there was no non-constant error variance, and after the predictor was included in the regression model, the remaining residual variability did not change into a function of something not in the model (Astivia & Zumbo, 2019; Cattaneo et al., 2018; Klein et al., 2016).

The data also do not experience symptoms of multicollinearity, which means that the independent variables in the multiple regression model do not have a very high correlation (Daoud, 2017; Jensen & Ramirez, 2013; Katrutsa & Strijov, 2017). Overall, the results of this classical assumption can be used to ensure certainty in the regression equation obtained, and the results are acceptable, unbiased, and consistent (Daoud, 2017; Mardiatmoko, 2019).

Table 4. The results of the classical assumption test

Classical Assumption Test	Criteria	Test Results				Conclusion
		X_1	X_2	X_3	Y	
Normality Test	Exact Sig. (2-tailed) > 0.05	0.073	0.367	0.229	0.053	All data are normally distributed
Linearity Test	Deviation from Linearity Sig. > 0.05.	0.108	0.727	0.910	-	There is a linear relationship between the independent variable and the dependent variable
Multicollinearity Test	VIF < 10.00	1.355	1.280	1.174	-	All data do not experience symptoms of multicollinearity
	Tolerance > 0.10	0.738	0.781	0.852	-	
Heteroscedas-ticity Test	Sig. > 0.05	0.834	0.285	0.231	-	All data do not experience symptoms of heteroscedasticity

Table 5 is the result of a series of multiple linear regression tests that show the results of the research hypothesis testing.

Table 5. The result of the multiple regression test

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	48.941	4.741		10.323	0.000
	X1	0.268	0.058	0.316	4.630	0.000
	X2	0.130	0.030	0.289	4.356	0.000
	X3	0.070	0.055	0.080	1.262	0.209

a. Dependent Variable: Y

The results can be interpreted as follows.

1. The regression model obtained is Y = 48.941 + 0.268(X1) + 0.130(X2) + 0.070(X3)
2. The constant (α) of 48.941 indicates that if the variables X_1, X_2, and X_3 have a score of 0 or constant, the Y value is 48.941.
3. The X_1 coefficient of 0.268 indicates that every increase in logical-mathematical intelligence will increase the prospective teachers' problem-solving by 0.268. This shows that the higher the logical-mathematical intelligence possessed by the teachers, the higher the level of mathematical problem-solving ability they have.
4. The X_2 coefficient of 0.130 indicates that every increase in visual-spatial intelligence will increase the prospective teachers' problem-solving by 0.130. This shows that the higher the

visual-spatial intelligence possessed by the teachers, the higher the level of mathematical problem-solving ability they have.

5. The X_3 coefficient of 0.070 indicates that each increase in intrapersonal intelligence will increase the prospective teachers' problem-solving by 0.070. This shows that the higher the intrapersonal intelligence possessed by the teachers, the higher the level of mathematical problem-solving ability they have.
6. The regression analysis of the effect of logical-mathematical intelligence on mathematical problem-solving resulted in a value of 0.316, t value of 4.630 with a significance of 0.000, which is < 0.05. This means that the higher the logical-mathematical intelligence possessed by the teachers, the more their mathematical problem-solving ability will increase. Thus, it can be concluded that logical-mathematical intelligence has a partially significant influence on the level of mathematical problem-solving.
7. The regression analysis of the effect of visual-spatial intelligence on mathematical problem-solving abilities yielded a value of 0.289, t value of 4.356 with a significance of 0.000, which is < 0.05. Hence, it can be concluded that visual-spatial intelligence has a partially significant effect on the level of mathematical problem-solving. This means that the higher the visual-spatial intelligence possessed by the teachers, the more their mathematical problem-solving ability increases.
8. The regression analysis of the influence of intrapersonal intelligence on mathematical problem-solving resulted in the value of 0.080, the t value of 1.262 with a significance of 0.209, which is > 0.05. In this case, it can be concluded that intrapersonal intelligence does not have a significant effect partially on the level of mathematical problem-solving ability. This means that the higher the intrapersonal intelligence of the teachers, their mathematical problem-solving ability does not increase.

Table 6. The result of the F test

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3272.187	3	1090.729	29.394	0.000[b]
	Residual	7532.664	203	37.107		
	Total	10804.850	206			

a. Dependent Variable: Y
b. Predictors: (Constant), X1, X2, X3

Table 6 shows that the sig. (0.000)< 0.05, meaning that variations in the changes of the value of mathematical problem-solving ability (Y) can be explained by variations in changes in the values of logical-mathematical intelligence (X_1), visual-spatial (X_2), and intrapersonal intelligence (X_3). Thus, it can be concluded that logical-mathematical intelligence (X_1), visual-spatial (X_2), and intrapersonal intelligence (X_3) simultaneously have a significant effect on mathematical problem-solving ability (Y).

The magnitude of the coefficient of determination of the influence of logical-mathematical intelligence (X_1), visual-spatial (X_2), and intrapersonal intelligence (X_3) on mathematical problem-solving abilities (Y) is shown in Table 7.

The R square value of X_1, X_2, and X_3 is 0.176, which means logical-mathematical intelligence (X_1), visual-spatial (X_2), and intrapersonal intelligence (X_3) can explain mathematical problem-solving ability (Y) by 30.3%, while the remaining 69.7% mathematical problem-solving ability is influenced by other variables not found in this study. The amount of the simultaneous contribution is the result of the sum of the contribution of the influence of each independent variable. Table 8 describes the partial contribution of each independent variable to the dependent variable.

Table 7. The result of the determination coefficient

Model Summary[b]				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.550[a]	0.303	0.293	6.092

a. Predictors: (Constant), X1, X2, X3
b. Dependent Variable: Y

Table 8. The result of the effective and relative contribution

Variable	Pearson Correlation	Standardized Coefficients (Beta)	Effective Contribution	Relative Contribution
X_1	0.475	0.316	0.150	0.495
X_2	0.453	0.289	0.131	0.432
X_3	0.275	0.080	0.022	0.073

Table 8 indicates that the effective contribution of X_1 is 0.150, which means that intrapersonal intelligence (X_1) can explain mathematical problem-solving ability (Y) by 15%. X_2 has an effective contribution of 0.131, which means that it can explain mathematical problem-solving ability (Y) by 13.1%. At the same time, X_3 has an effective contribution of 0.022, which means that it can explain mathematical problem-solving ability (Y) by 2.2%. If all the effective contributions of each of these independent variables are added up, a value of 0.303 is obtained, which is equivalent to the value of the coefficient of determination of the simultaneous influence contribution.

Furthermore, on the relative contribution, X_1 has a value of 0.495. This means that logical-mathematical intelligence contributes 49.5% of the total contribution of the simultaneous influence of the three independent variables on the dependent variable. The X_2 variable has a value of 0.432, which means that visual-spatial intelligence has a contribution of 43.2% of all the contributions of the three independent variables. The X_3 variable has a value of 0.073 which means that intrapersonal intelligence contributes 7.3% of all simultaneous contributions from all independent variables to the mathematical problem-solving abilities of the prospective teachers.

Discussion

Logical-mathematical intelligence partially has a significant effect on mathematical problem-solving ability. This result is in line with several studies that have also found a positive effect of logical-mathematical intelligence on problem-solving ability (Asmal, 2020; Azinar et al., 2020; Etchepare et al., 2011; Zulkarnain & Nurbiati; 2019). This type of intelligence plays an important role in one's mathematical ability (Estri & Ibrahim, 2021; Sukardjo & Yusdiningtias, 2018). In essence, this intelligence is indeed standardized as a parameter of achievement of abilities in the field of mathematics (Dara & Budiarto, 2018; Putri, 2018). The indicators of logical-mathematical intelligence are fully related to the components contained in mathematics lessons and their learning activities (Asmal, 2020; Wulandari & Fatmahanik, 2020). This is the main reason why various studies have succeeded in proving logical-mathematical intelligence as a predictor of mathematical problem-solving ability. For example, the ability to hypothesize plays an important role in planning solutions and making decisions about the type of problem solution. In addition, mathematical problems certainly require various mathematical calculation skills, which is also part of logical-mathematical intelligence (Estri & Ibrahim, 2021).

Visual-spatial intelligence also has a significant effect on mathematical problem-solving ability partially. The results are consistent with some previous research that found the same results (e.g., Akhmad, 2019; Battista et al., 1982; Delgado & Prieto, 2004; Adams et al., 2022; Maharani & Slamet, 2019; Sorby & Veurink, 2019) and less consistent with studies that found otherwise (Hawes et al., 2015; Lowrie et al., 2017). Similar to logical-mathematical intelligence, the reason that visual-spatial intelligence can contribute to mathematical problem-solving abilities is also that this relates to the components of mathematics lessons and various activities in learning (Ahmad & Etmy, 2019; Kyttälä & Lehto, 2008; Newcombe et al., 2019; Weckbacher & Okamoto, 2014). It is the ability to visualize space and objects in mind (Novitasari et al., 2015; Šafranj& Zivlak, 2018). Because of this capacity, the students can easily activate their imagination and creativity by imagining concrete to abstract mathematical objects in their thoughts and, at the same time, pouring them into real works (Sadeghi & Farzizadeh, 2012). But the influence of visual-spatial intelligence is only limited to several types of mathematical topics, including (1) geometry and measurement and (2) numbers and algebra (Battista et al., 1982; Delgado & Prieto, 2004; Kyttälä & Lehto, 2008). In addition, whether there is an influence of visual-spatial intelligence is also influenced by the type and period of development of this intelligence (Hawes et al., 2017; Lowrie et al., 2017). This is why several studies obtained results that are not in line with this study.

Unlike the previous bits of intelligence, intrapersonal intelligence partially does not significantly affect students' mathematical problem-solving ability. This result is in line with several studies which also found a non-significant effect (Dacillo, 2018; Mahmud & Amaliyah, 2017; Supardi, 2013) and is not in line with several previous studies that showed a significant effect (Aswin et al., 2021; Mulbar, 2019). Intrapersonal intelligence is a person's ability to recognize one's feelings, level of emotional reaction, and thought processes to evaluate oneself and set self goals Pehlivan & Durgut, 2017). In general, someone with this intelligence has a good ability to recognize oneself and every aspect related to themselves (Paradita et al., 2019). This ability to understand their internal cannot be a guarantee that students will also be able to understand external things outside themselves well. One of the external aspects that are not always manageable to understand by students who have intrapersonal intelligence is the mathematical problem (Dacillo, 2018).

One of the causes that have the potential to make intrapersonal intelligence not affect mathematical problem-solving ability is the high self-efficacy of the students (Abdi et al., 2020; Guseh et al., 2015; Zhoc et al., 2018). A person with high intrapersonal intelligence has a sense of comfort, satisfaction, and positive thinking about themselves and all the efforts he/she has made (Mahmud & Amaliyah, 2017). This kind of attitude is likely to bring high self-confidence in working on mathematical problems and optimism that the results of the work are appropriate (Vongkrahchang & Chinwonno, 2016). This has the potential to foster an over-optimistic attitude, not be afraid of making mistakes, and feel that even unfavorable results can still be overcome after self-reflection (Mahmud & Amaliyah, 2017). In addition, Supardi (2013) also adds that the cause of intrapersonal intelligence that does not affect problem-solving abilities is the opportunity for intrapersonal intelligence to hamper the simplicity of problem-solving. This intelligence has the potential to complicate the solving of mathematical problems, which should be the easiest and simple solution (Supardi, 2013). This side of intrapersonal intelligence does not support improving students' mathematical problem-solving abilities.

Although intrapersonal intelligence does not have a significant effect on problem-solving abilities, this intelligence still has its contributions to influencing mathematical problem-solving abilities. Someone with high intrapersonal intelligence tends to have high motivation as well (Aswin et al., 2021). Thus, they generally do not give up easily when they encounter difficulties in learning so that mathematical problem-solving is achieved (Abdi et al., 2020; Okwuduba et al., 2021). Students who have intrapersonal intelligence can make good plans, recognize their own emotions and manage themselves. Thus, they are always disciplined and concentrate on learning which will certainly make it easier to understand mathematical problems (Auliana & Andayani, 2021; Swart, 2021). Thus, in several studies, intrapersonal intelligence can still influence mathematical problem-solving abilities.

In terms of partial effect, not all intelligence has an influence, but the results of the study show that logical-mathematical, visual-spatial, and intrapersonal intelligence simultaneously influence mathematical problem-solving ability. This shows that several types of intelligence simultaneously influence problem-solving abilities (Janawi, 2013; Novitasari et al., 2015). In addition, because the three independent variables are categorized in multiple intelligences, these results strengthen relevant research that there is a relationship between students' multiple intelligences and mathematical problem-solving abilities (Abdi et al., 2013; Ahvan et al., 2016; Fitri, 2020; Perez et al., 2014; Rahbarnia et al., 2014). Even though these intelligences simultaneously have a significant influence, one of them, namely intrapersonal intelligence, partially has no significant effect. This result can be interpreted that high intrapersonal intelligence can be followed by high mathematical problem-solving ability on the condition that the student must also have high logical-mathematical and visual-spatial intelligence.

Each indicator of the three types of intelligence has an influence on mathematical problem-solving abilities. Logical-mathematical intelligence indicators such as reasoning, analyzing, linking patterns, information, and relationships, as well as careful thinking, are needed in every step of solving mathematical problems (Arum et al., 2018; Fatimah et al., 2020). Meanwhile, visual-spatial intelligence plays an important role in visualizing problem objects (Pehlivan & Durgut, 2017; Šafranj & Zivlak, 2018). And lastly, although not directly involved in mathematical calculations, intrapersonal intelligence is fully involved in maintaining psychological conditions when solving mathematical problems (Okwuduba et al., 2021; Perez & Ruz, 2014). Karamikabir (2012) also suggests that (1) logical-mathematical also plays an important role as the imagination of problem, a method for founding formula, illustrating criterion, analysis, design, and argue for a better way for founding range; (2) visual-spatial also plays a role in recall graph, comparison domain and range, founding formula based on the graph, drawing diagram, distinguishing from a graph, and found a better way to evaluate graph; and (3) intrapersonal has a role in recall experiments, founding values, personalize extend definition, categorize formulation, compose relations between concepts, and solve problems. Overall, Karamikabir (2012) summarizes that solving mathematical problems requires discovery and reasoning by logical-mathematical intelligence, theory-building by intrapersonal intelligence, and visualization of objects by visual-spatial intelligence. Thus, these three types of intelligence can work together in contributing to mathematical problem-solving ability.

Conclusion and Implication

This study found that logical-mathematical and visual-spatial intelligence has a partially significant effect on the prospective primary teachers' mathematical problem-solving ability. On the other hand, intrapersonal intelligence does not have a significant effect on mathematical problem-solving ability partially. Meanwhile, simultaneously, the three influence the teachers' mathematical problem-solving ability. The effective contribution of each intelligence from X_1 to X_3 is 15%, 13.1%, and 2.2%, respectively. This means that the coefficient of determination from the combination of these three variables reaches 30.3% of the prospective teachers' mathematical problem-solving ability. Therefore, it can be concluded that prospective teachers who have high logical-mathematical, visual-spatial, and intrapersonal intelligence will also improve their mathematical problem-solving ability.

The implications that can be considered in the implementation of mathematics learning based on the research findings are the planning of a series of learning models based on the dominant type of intelligence and the unique combination of several appropriate intelligence that can affect students' mathematical problem-solving ability. By choosing the right intelligence-based learning, students' mathematical problem-solving abilities can also be supported. Several types of intelligence that have an influence are logical-mathematical, visual-spatial, and intrapersonal intelligence. In this case, the application of learning mathematics with the development of this intelligence is quite important. The practical implication of this research is that it can be used as a reference for educators in the field of mathematics in planning multiple intelligence-based learning.

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