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Contribution of mathematics anxiety, achievement motivation, and academic potential to problem solving ability

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Abstract

The purpose of this research was to determine the contribution of mathematics anxiety, achievement motivation, and potential academic towards mathematics problem solving ability. The population of this research was 3791 students at class VII public junior high school in Denpasar City. The sample of this study consisted of 483 students who were obtained using proportionate cluster random sampling. The type of this research was ex post facto with path analysis technique. The data of mathematics anxiety and achievement motivation were collected by questionnaires, while the data of potential academic and mathematics problem solving ability were collected by tests. Results showed that (1) mathematics anxiety directly affected potential academic in inverse correlation with contribution of 24.2%, (2) achievement motivation directly affected potential academic in positive correlation with contribution of 62.4%, (3) mathematics anxiety directly affected mathematics problem solving ability in inverse correlation with contribution of 43.1%, (4) mathematics anxiety directly affected mathematics problem solving ability in positive correlation with contribution of 2.6%, (5) achievement motivation directly affected mathematics problem solving in positive correlation with contribution of 41.2%, (6) achievement motivation indirectly affected mathematics problem solving ability in positive correlation with contribution of 6.7%, (7) potential academic directly affected mathematics problem solving ability in positive correlation with contribution of 10.7%, (8) mathematics anxiety and achievement motivation simultaneously affected potential academic in positive correlation with contribution of 69.2% (9) mathematics anxiety, achievement motivation, and potential academic simultaneously affected mathematics problem solving ability in positive correlation with contribution of 79.4%.

Keywords: *mathematics anxiety; achievement motivation; potential academic; mathematics problem solving ability*

Introduction

Mathematics is seen as a major stressor in the learning process at school. Also, the high level of anxiety in learning mathematics leads to the dislike of mathematics. Many students who experience math anxiety have little confidence in their ability to do mathematics and tend to take a few subjects related to mathematics or numeracy, and mostly restrain career choices (Scarpello, 2007). Akinsola (2008) in his research of 122 mathematics teachers, found that mathematics anxiety, the belief in mathematics teaching, locus of control, and learning habits correlated significantly with mathematical problem solving abilities. In that study, mathematics teacher's math anxiety was the highest, and their study habits were the lowest. Furthermore, the interesting thing to study in the next research was to find out how contribution of mathematics anxiety to problem solving abilities, where secondary school children were used as the samples. Ramirez et al. (2015) found that there was the most negative relationship between mathematics anxiety and mathematical problem solving strategies of children in class I and class II elementary schools with the highest working memory capacity. Ironically, students with high cognitive capacity avoided using problem solving strategies when they were in high mathematics anxiety. The research emphasized the relationship of mathematics anxiety to problem solving strategy.

Reeve et al. (2009) found that anxiety in learning that was measured using the Classical Test Theory formula had a significant negative effect on students' cognitive abilities. Cognitive ability is related to the academic potential that each individual brings from birth. Furthermore, it is worth investigating the contribution of anxiety in learning mathematics towards students' academic potential. Weems et al. (2009) also found that mathematical anxiety had a significant effect on academic potential in minority victims of Hurricane Katrina in New Orleans. The results of this research become interesting when compared with similar research conducted on public school students in Denpasar City. Increased competency using Dweck's Social-Cognitive Theory as part of achievement motivation is closely related to cognitive intelligence possessed by students, as the results of research conducted by Dupreyat & Marine (2005). Academic potential is related to students' cognitive intelligence. Therefore, it is worth investigating the contribution of achievement motivation to students' academic potential. Luster et al. (2004) found that achievement motivation in the academic field of students influenced receptive language intelligence of 4.5 years old (born to teenagers and low-income mothers). Language intelligence (verbal intelligence) is one part of the potential academic. For the next research, the contribution of achievement motivation to the overall academic potential (which includes verbal intelligence, quantitative intelligence and reasoning intelligence) becomes interesting to do.

In mathematics learning, another important variable that cannot be ignored is achievement motivation. Apriyani (2017) found that there was a positive correlation between achievement motivation and mathematical problem-solving ability of students of class XI of Jatilawang Technology Vocational School. Stanly (2014) concluded that there was a significant difference between achievement motivation and problem solving skills in students of class IX public schools in Puducherry. Stanly also found that both male and female students had the same level of achievement motivation and mathematical problem solving skills. Students in public schools also had a higher level of achievement motivations and mathematical problem solving abilities than those in private schools in the city.

Learning process has rarely empowered the academic potential of students as well as the goals of national education. The various potential academic of each student is rarely considered by the teacher. Most teachers chose the learning strategy to increase students' problem solving than to maximize students' potential academic variable. Also, previous research found that potential academic did not significantly influence problem solving abilities, critical thinking and metacognitive awareness of high school students in biology learning (Karmana, 2013). Nurlaeli & Sariyasa (2016) pointed out that there was no interaction between the learning model and potential academic on students' problem solving abilities at Terara 1 Junior High School.

Problem solving ability is important in learning mathematics. However, there are lacks of researches focusing on variables influencing problem solving simultaneously. Therefore, the objective of this research was to study the contribution of mathematics anxiety, achievement motivation and potential academic towards mathematical problem solving ability of public junior high school students in Denpasar City.

Materials and Methods

This research was ex post facto with quantitative approach. This research was conducted in April 2018 to May 2018. The population was all students of class VII SMP Negeri in Denpasar City, which consists of 12 schools. The sampling technique used in this research was proportionate cluster random sampling, a combination of cluster random sampling and proportionate random sampling. The technique of cluster random sampling was applied to select the sample of schools by category region, i.e., one school in North of Denpasar Cty, one school in East Denpasar, one school in South Denpasar, and one school in West Denpasar. The chosen samples were 87 students in SMPN 12 Denpasar, 77 students in SMPN 1 Denpasar, 93 students in SMPN 6 Denpasar, and 92 students SMPN 7 Denpasar. Data instruments for this study were questionnaires and tests which were evaluated for their validity and reliability prior to further analysis. Data evaluation was performed using SPSS 22 for Windows.

Prior to data classification, mean ideal (Mi) and standard deviation (SDi) were calculated using the following equation.

$$M_i = \frac{1}{2}(\text{high score ideal} + \text{low score ideal})$$

$$SD_i = \frac{1}{6}(\text{high score ideal} - \text{low score ideal})$$

Data mathematics anxiety (MA), achievement motivation (AM), and academic potential (AP) were classified using Table 1, whereas mathematics problem solving ability (MPSA) was classified using Table 2.

Table 1. Classification of mathematics anxiety (MA), achievement motivation (AM), and potential academic (PA)

No	Range	Category
1	$x \geq M_i + 1.5SD_i$	Very High
2	$M_i + 0.5SD_i \leq x < M_i + 1.5SD_i$	High
3	$M_i - 0.5SD_i \leq x < M_i + 0.5SD_i$	Medium
4	$M_i - 1.5SD_i \leq x < M_i - 0.5SD_i$	Low
5	$x < M_i - 1.5SD_i$	Very Low

Table 2. Classification of mathematics problem solving ability (MPSA)

No	Range	Category
1	$y \geq M_i + 1.5SD_i$	Excellence
2	$M_i + 0.5SD_i \leq y < M_i + 1.5SD_i$	Good
3	$M_i - 0.5SD_i \leq y < M_i + 0.5SD_i$	Medium
4	$M_i - 1.5SD_i \leq y < M_i - 0.5SD_i$	Less Good
5	$y < M_i - 1.5SD_i$	Bad

Furthermore, we performed normality test, linearity test and the significance of the regression, multicollinearity test, autocorrelation test, and heteroscedasticity test to test whether the collected data meet requirements to be analyzed using path analysis.

Results and Discussion

The descriptive statistics with the help of Table 1 and Table 2 implied that students had medium MA, AM, PA, and MPSA. Data normality test using Kolmogorov-Smirnov showed that the data were distributed normally. An F test was carried out to evaluate the data linearity and regression significance. The test concluded that there was linear regression between MA with PA, AM with PA, MA with MPSA, AM with MPSA, and PA with MPSA. Furthermore, a multicollinearity and an autocorrelation test were conducted and resulted that there were no multicollinearity and autocorrelation. Additionally, a heteroscedasticity test was performed and found no heterocedasticity in the variables.

Path Analysis

Model causal relationships appreciation of MA (X_1), AM (X_2), and PA (X_3) on MPSA (Y) tested in this study was presented in Fig. 1. In this study, for path analysis, the structure of the relationship was divided into the substructure of the track, which were the first model and the second model, where the equations the first model is $X_3 = P_{31}X_1 + P_{32}X_2 + P_3\varepsilon_3$ and the equation of the second model is $Y = P_{Y1}X_1 + P_{Y2}X_2 + P_{Y3}X_3 + P_Y\varepsilon_Y$.

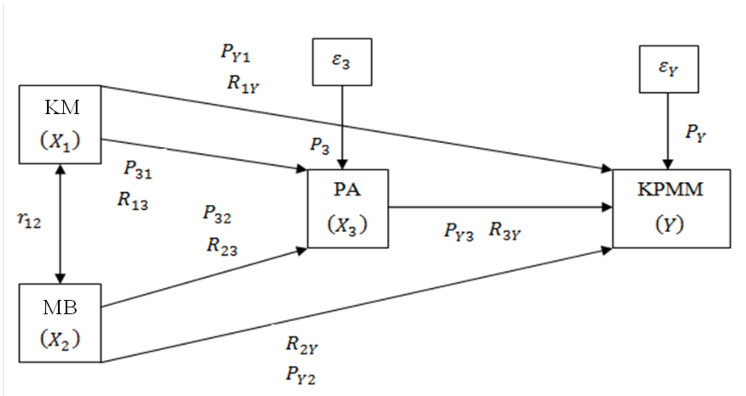

Figure 1. Path Diagram of X_1, X_2, X_3 Towards Y

The path coefficient calculation of the first model obtained the equation:

$$X_3 = -0.242X_1 + 0.624X_2 + 0.555\varepsilon_3$$

Simultaneously test was then performed to test the hypothesis:

$$H_0: P_{31} = P_{32} = 0$$

$$H_1: P_{31} \neq 0 \text{ and } H_1: P_{31} \neq 0$$

Correlation test implied that the correlation was significant. Analysis of variance of the first model concluded that MA and AM contributed simultaneously to the PA, thus the test path coefficient individually can be done.

An individual test of MA and PA was done by testing the hypothesis:

$$H_0: P_{31} = 0$$

$$H_1: P_{31} \neq 0$$

whereas P_{31} was the coefficient of the contribution of MA on PA.

The analysis of individual lines the path coefficient for the variable MA: P_{31} = -0.242. t value obtained was -5.649 with sig. of 0.000 (Table 3). Because the value of sig.< 0.05 then H_0 was rejected. This means that MA contributed directly and significantly to PA. The correlation test also showed that MA and PA had a significant inverse correlation.

The coefficient of AM contribution to PA was expressed by the path coefficient P_{32}. Testing individually was done to test the hypothesis as follows:

$$H_0: P_{32} = 0$$

$$H_1: P_{32} \neq 0$$

Tabel 3. The first model coefficients

Model	Beta	t	Sig.
Math anxiety	-.242	-5.649	.000
Achievement motivation	.624	14.589	.000

The analysis of individual lines the path coefficient for the variable AM: P_{32} = 0.624. t value obtained was 14.589 with sig. of 0.000 (Table 3). Because the value of sig.< 0.05 then H_0 was rejected. This means that AM contributed directly and significantly to PA. The correlation test also showed that AM and PA had a significant positive correlation.

The path coefficient calculation of the second model obtained the equation.

$$Y = -0.431X_1 + 0.412X_2 + 0.107X_3 + 0.454\varepsilon_Y$$

Simultaneously test was then performed to test the hypothesis:

$$H_0: P_{Y1} = P_{Y2} = P_{Y3} = 0$$

$$H_1: P_{Y1} \neq 0,\ P_{Y2} \neq 0,\ P_{Y3} \neq 0$$

Correlation test implied that the correlation was significant. Analysis of variance of the second model concluded that MA, AM, PA contributed simultaneously to the MPSA, thus the test path coefficient individually can be done.

Individual test of MA and MPSA was done by testing the hypothesis:

$$H_0: P_{Y1} = 0$$

$$H_1: P_{Y1} \neq 0$$

whereas P_{Y1} was the coefficient of the contribution of MA on MPSA.

The analysis of individual lines the path coefficient for the variable MA: P_{Y1} = -0.431. t value obtained was -11.899 with sig. of 0.000 (Table 4). Because the value of sig.< 0.05 then H_0 was rejected. This means that MA contributed directly and significantly to MPSA. The correlation test also showed that MA and MPSA had a significant inverse correlation.

An individual test of AM and MPSA was done by testing the hypothesis:

$$H_0: P_{Y2} = 0$$

$$H_1: P_{Y2} \neq 0$$

The analysis of individual lines the path coefficient for the variable AM: P_{Y2} = 0.412. t value obtained was 9.785 with sig. of 0.000 (Table 4). Because the value of sig.< 0.05 then H_0 was rejected. This means that AM contributed directly and significantly to MPSA.

Table 4. The second model coefficients

Model	Beta	t	Sig.
Mathematics Anxiety	-.431	-11.899	.000
Achievement Motivation	.412	9.785	.000
Potential Academic	.107	2.864	.004

The correlation test also showed that AM and MPSA had a significant positive correlation.

An individual test of PA and MPSA was done by testing the hypothesis:

$$H_0 : P_{Y3} = 0$$

$$H_1 : P_{Y3} \neq 0$$

The analysis of individual lines the path coefficient for the variable PA: $P_{Y3} = 0.107$. t value obtained was 2.864 with sig. of 0.000 (Table 4). Because the value of sig.< 0.05 then H_0 was rejected. This means that AM contributed directly and significantly to MPSA. The correlation test also showed that PA and MPSA had a significant positive correlation.

Based on the results of the path coefficient of the model one and model two, it can be described in the overall relationship between the causal variable MA (X_1), AM (X_2), and PA (X_3) on the MPSA (Y) like the Figure 2.

Goodnes-of-fit test

Goodness-of-fit test was carried out to analyze the fitness of the model with the data using model trimming. Result showed that the obtained coefficient of determinant for the first and second model:

$$\begin{aligned} R_m^2 &= 1-(1-R_{123}^2)(1-R_{123Y}^2) \\ &= 1-(1-0.692)(1-0.794) \\ &= 1-(0.308)(0.206) \\ &= 1-0.063 \\ &= 0.936 \end{aligned}$$

Because the proposed model is not improved, thus $R_M^2 = M = 0.936$. The Q value could be calculated as follows:

$$Q = \frac{1-R_m^2}{1-M} = \frac{1-0.936}{1-0.936} = 1$$

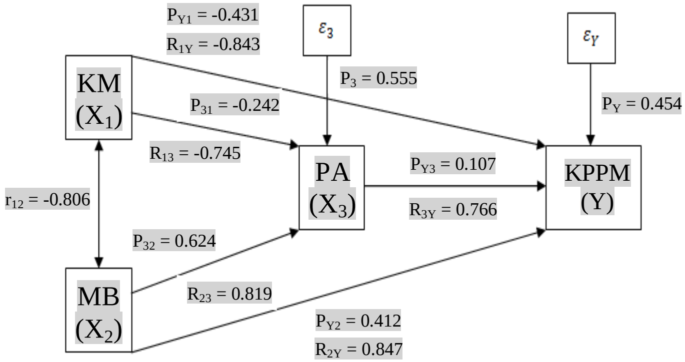

Figure 2. Diagram and path coefficients of the causal relationships X_1, X_2, X_3 Towards Y

The value of Q was 1 indicating that the model fitted perfectly, thus Q value did not need to be tested by using the statistic W. It also showed that the model of the causal relationship of the variables of MA (X_1), AM (X_2), and PA (X_3) on the MPSA (Y) which was obtained by perfect fit or appropriate. Furthermore, we determined the contribution of direct and indirect MA (X_1), AM (X_2), and PA (X_3) on MPSA (Y) as follows. (a) Analysis of the influence of MA on PA obtained a significance value of MA was smaller than alpha (5%), thus it can be concluded that MA had a significant effect directly on PA. MA contributed directly and adversely by $P_{31} = 0.242 \times 100\% = 24.2\%$ to PA and relationship in the opposite direction of the second variable (R_{13}) was equal to 0.745. (b) Analysis of the influence of AM on PA obtained a significance value of achievement motivation was smaller than alpha (5%), thus it could be concluded that AM had a significant effect directly to PA. The direct contribution of AM to PA was equal to $P_{32} = 0.624 \times 100\% = 62.4\%$ and the relationship between the two variables (R_{23}) was equal to 0.819. (c) Analysis of the influence of AM on MPSA obtained a significance value of math anxiety was smaller than alpha (5%), thus it could be concluded that MA had a significant effect directly on MPSA. The direct contribution of MA to MPSA was equal to $P_{Y1} = 0.431 \times 100\% = 43.1\%$ and the relationship was the opposite of the two variables (R_{1Y}) was equal to 0.843. (d) Analysis of the influence of MA through PA on MPSA showed that there was indirect influence by $P_{31}.P_{Y3} = (-0.242)(0.107) = -0.026$ or 2.6%, thus the contribution of total MA on MPSA through PA was equal to $P_{Y1} + P_{31}.P_{Y3} = (-0.431) + (-0.026) = -0.457$ or 45.7%. Because the result was higher than 0.431, it could be concluded that the indirect MA through PA affected MPSA significantly. (e) Analysis of the influence of AM on MPSA obtained a significance value of AM was smaller than alpha (5%), thus it can be concluded that AM had a significant effect directly on MPSA. The direct contribution of AM to MPSA was by $P_{Y2} = 0.412 \times 100\% = 41.2\%$ and the relationship between the two variables (R_{2Y}) was equal to 0.847. (f) Analysis of the influence of AM through AP on MPSA by $P_{32}.P_{Y3} = (0.624)(0.107) = 0.067$ or 6.7%, thus total contributions of AM to MPSA through PA was equal to $P_{Y2} + P_{32}.P_{Y3} = (0.412) + (0.067) = 0.479$ or 47.9%. Because the result was higher than 0.412, it could be concluded that the indirect AM through PA affected MPSA significantly. (g) Analysis of the influence of PA on MPSA obtained a significance value of PA was smaller than alpha (5%), thus it could be concluded that PA had a direct effect on MPSA. The direct contribution of PA on MPSA was by $P_{Y3} = 0.107$ or 10.7% and the relationship of the two variables (R_{3Y}) was equal to 0.766. (h) The contribution of MA and AM simultaneously on PA (R^2_{123}) was equal to 0.692. Thus it could be concluded that there was an influence of MA and AM to MPSA with a large contribution of 69.2%. The magnitude of the relationship between MA and AM simultaneously on PA (R_{123}) was 0.832. (i) The contribution of MA, AM, and PA to MPSA (R^2_{123Y}) was equal to 0.794. Thus, it could be concluded that there was an influence of MA, AM, and PA on MPSA by 79.4%. The magnitude of the relationship between simultaneous MA, AM, and PA to MPSA (R_{123Y}) was 0.891 (Table 5).

Table 5. Direct contribution, indirect contribution, and total contribution from causal relation X_1, X_2, X_3, to Y

Contributions Between Variables	Path Coefficient (Determination)	Direct Contribution	Indirect contributions through X_3	Residue	Total
X_1 towards X_3	0.242	24.2%	-	-	24.20%
X_2 towards X_3	0.624	62.4%	-	-	62.40%
X_1, X_2 towards X_3	0.692	69.2%	-	30.80%	100.00%
X_1 towards Y	0.422	43.1%	2.6%	-	45.70%
X_2 towards Y	0.423	41.2%	6.7%	-	47.90%
X_3 towards Y	0.107	10.7%	-	-	10.7%
X_1, X_2, X_3 towards Y	0.794	79.4%	-	20.60%	100.00%

Conclusion

Path analysis implied that: (1) math anxiety had a direct inverse effect on potential academic significantly, (2) achievement motivation had a direct positive effect on potential academic significantly, (3) math anxiety contributes had direct inverse effect on mathematics problem solving ability significantly, (4) math anxiety had indirect positive effect on mathematics problem solving ability significantly, (5) achievement motivation had a direct positive effect on mathematics problem solving ability significantly, (6) achievement motivation had an indirect positive effect on mathematics problem solving ability significantly, (7) potential academic had direct positive effect on mathematics problem solving ability significantly, (8) math anxiety and achievement motivation had positive simultaneous effect on potential academic significantly, (9) math anxiety, achievement motivation, and potential academic had positive simultaneous effect on mathematical problem solving ability significantly.

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