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The Contribution of Mathematical Connection and Mathematical Communication to Problem Solving Ability

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Abstract: ***The purpose of this study was to determine the direct and indirect effects of three latent variables (mathematical communication skills, mathematical connections and problem solving). This was a survey research conducted in senior high schools throughout the Kota Bengkulu. The sample of this study amounted to 170 students. There are three research instruments namely problem solving ability test, mathematical connection ability test and mathematical communication test. The results: there was a positive direct effect of mathematical connection skills on problem solving abilities. Second, there was a positive direct effect of mathematical communication skills on mathematical connection skills. Also, there was an indirect effect of mathematical communication skills on problem solving abilities through mathematical connections.***

Keywords: Mathematical Connection, Mathematical Communication, Problem Solving Ability

1. Preliminary

Mathematics is an important and compulsory subject for senior high school students.It is important for transferring mathematical knowledge and skills acquired in school to real life that require individuals to think, calculate, estimate or apply mathematical knowledge to solve real life problems and also to communicate mathematically (Baki, Çatlıoglu, Costu, & Birgin, 2009). Problem solving ability is one of the goals of mathematics learning.It is a critical component of a comprehensive 21st century education (Wismath, Orr, & Zhong, 2014). The problem solving was contains the element of nonroutine. Mathematics educators state that problem solving occurs only when the problem is nonroutine to the solver. For solver, the method is not immediately obvious. But, the mathematicians do not consider if the solver views the problem as routine or knows the method immediately, as long as the method is not specified in the problem(Latterell, 2000).Therefore, the main skills students must develop today are critical thinking and problem solving, creativity and innovation, and collaboration and communication (Wismath et al., 2014).

According to Einstein, the problem solving is the heart of learning mathematics. The importance of learning mathematics is to develop problem solving skills in mathematics and to find solutions to problems in everyday life (Chowdhury, 2016). Therefore, mathematics is an excellent vehicle for developing students' intellectual competencies in logical reasoning, spatial visualization, analysis, and abstract thinking (Akinmola, 2014). Students 'experience in solving problems is very important to develop students' thinking skills and help them gain more skills in solving problems in everyday life (Chowdhury, 2016). The teacher was needs to be equipped with the pedagogical strategies needed to teach problem solving skills effectively (Mataka, Cobern, Grunert, Mutambuki, & Akom, 2014).Mathematics teachers must always strive to develop problem-solving skills in students who will help them solve everyday problems and improve sustainable learning in the 21st century. (Akinmola, 2014).

Research on problem solving abilities showed that reading errors were 4.35%, understanding errors were 17.39%, transformation errors were 34.78%, process skill errors were 23.91%, and insertion errors were 19.57%.The results of other studies show that context-based learning can effectively enable students to develop a complete problem solving process. In this case, context simulation is useful for fostering students' ability to build and analyze questions and then choose and develop solutions. Also, project design develops students' ability to evaluate results and apply feedback(Yu, Fan, & Lin, 2015).In learning mathematics, students should have good mathematical communication. Students must have mathematical connection skills. These students will easily solve mathematical problems.

The mathematics teachers was to discuss the concepts associated with, strategies to improve, the goals and benefits and application of mathematical communication and the impact of mathematical communication on thinking skills(Kaya, 2016).Mathematical communication can foster student involvement and participation in understanding mathematical concepts. One of the challenges to creating meaningful communication and class discourse is a change in epistemology by teachers and students. The teacher's view of how students learn mathematics and their role in class is very important for creating learning opportunities for all students (Pourdavood & Wachira, 2015).

The results showed that the connection of mathematics to real life was largely in the context of real life and professional life categories (there were 88.7% of students). However, they felt a low benefit in teaching real-life mathematics (ie 14.7%) for the same category (Baki et al., 2009). Other research shows that after students 'initial abilities are controlled, students' mathematical understanding skills in applying realistic mathematics learning approaches are higher than those taught by applying conventional learning. Also, the average ability of mathematical understanding of students who study ethnomathemically oriented material is higher than students who are given non-ethnomathematics material(Widada,

Herawaty, & Lubis, 2018).The results showed that students could develop the ability to solve problems through self-reflection on planning, monitoring and evaluating the implementation of thinking processes. Students could combine pieces of information about the parts of the traditional house of Rejang Lebong that have similar properties to the mathematical 3-dimensional figures such as pyramids, prisms, rectangular prism, and cubes (Herawaty, Widada, Novita, Waroka, & Lubis, 2018).

According to (Herawaty & Widada, 2018), that the ability to solve mathematical problems was an ability to search for and produce a solution of the mathematical problem with various activities: understanding the given problem; creating mathematical models; solving problems according to the mathematical model made; and interpreting the solutions.Problem solving abilities of students who learn with realistic mathematical approaches are better than students who learn with conventional approaches (Herawaty & Rusdi, 2016). Therefore, to be able to solve mathematical problems, students must have mathematical communication skills and mathematical connections properly.

The communication and oral and written discourse of students should not be underestimated. Communication and class discourse fulfills three broad and interrelated goals for learning, teaching and assessment. First, when students communicate their thinking and mathematical reasoning, they become observers themselves. They make mathematical solutions that are not seen more clearly and seen by themselves and their peers. In addition, when they explain their thoughts and problem solving to their peers, they become teachers in the class. They become more confident in their ability to do significant mathematics (Pourdavood & Wachira, 2015).

Indicators of mathematical problem solving abilities are (1) understanding problems (identifying problems and making mathematical models); (2) solving problems based on mathematical models; (3) answer the problem (Herawaty, Widada, et al., 2018)(Widada, Herawaty, & Agustina, 2018). According to (Sumarno, 2003), students' mathematical connection ability can be seen from the following indicators: (1) recognizing equivalent representations of the same concept; (2) recognize the relationship of mathematical procedures to a representation to equivalent representation procedures; (3) use and assess the interrelationships between mathematical topics and the interrelationships outside mathematics; and (4) using mathematics in everyday life.The mathematical communication indicators are (1) drawing ability; (2) the ability to make mathematical expressions; (3) the ability to write answers in their own language (Herawaty, Gusri, Saputra, Liana, & Aliza, 2018)(Widada, Herawaty, Yanti, & Izzawati, 2018). Thus, it needs to be empirically tested about the contribution of mathematical communication skills and mathematical connections to mathematical problem solving abilities.

2. Method

This study is a survey research. The population was all senior high school students in the Kota Bengkulu. Randomly selected samples of 170 students. There are three latent variables. These are three abilities: mathematical problem solving, mathematical connections and mathematical communication. Research instruments are tests of mathematical problem solving abilities, mathematical communication tests and mathematical connection tests. Data were analyzed by using Confirmatory Factor Analysis (CFA).

3. Results and Discussions

The data of the test were the ability to mathematical problem solving (= sol), ability to mathematics connection (=con) and math communication ability (= comm) as latent variables.The variable indicators of mathematical problem solving abilities are (X1) understanding problems (identifying problems and making mathematical models); (X2) solving problems based on mathematical models; (X3) answer the problem. The mathematical connection ability have four indicators: (X4) recognizing equivalent representations of the same concept; (X5) recognize the relationship of mathematical procedures to a representation to equivalent representation procedures; (X6) use and assess the interrelationships between mathematical topics and the interrelationships outside mathematics; and (X7) using mathematics in everyday life. Also, mathematical communication indicators are (X8) drawing ability; (X9) the ability to make mathematical expressions; (X10) the ability to write answers in their own language.

The data were analyzed by using Lisrel 8.8. The results of data analysis are presented in Figure 1 Basic Model Standardized Solution.

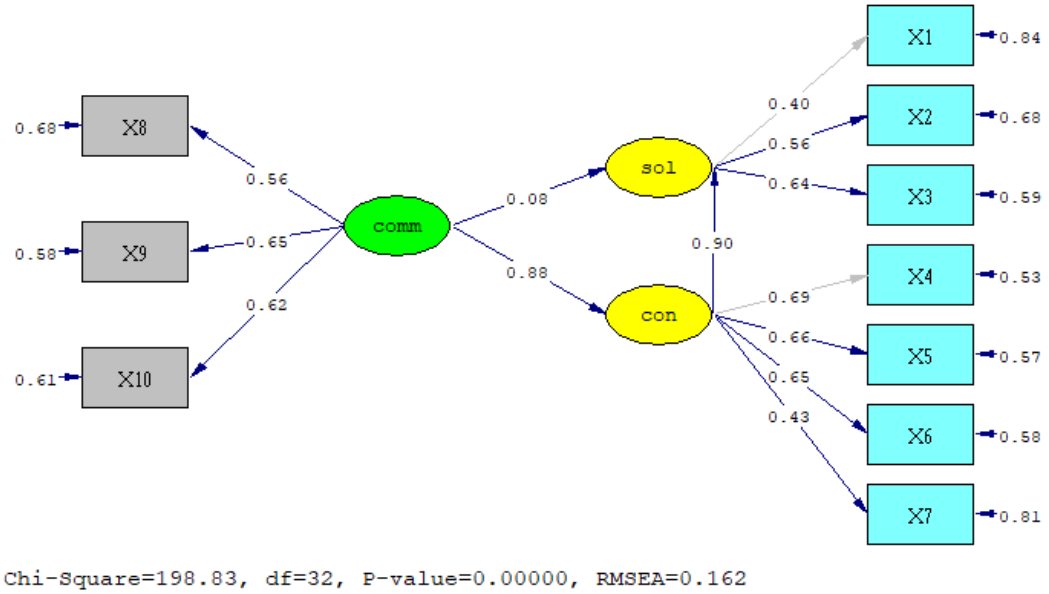

Figure 1: Basic Model Standardized Solution

The path diagram of the Lisrel test results was presented in Figure 2 (ie the Basic Model T-Values). These diagram determines the significance of the direct and indirect effect between latent variables. This was a statistical hypothesis test to determine whether the research hypothesis is accepted or rejected.

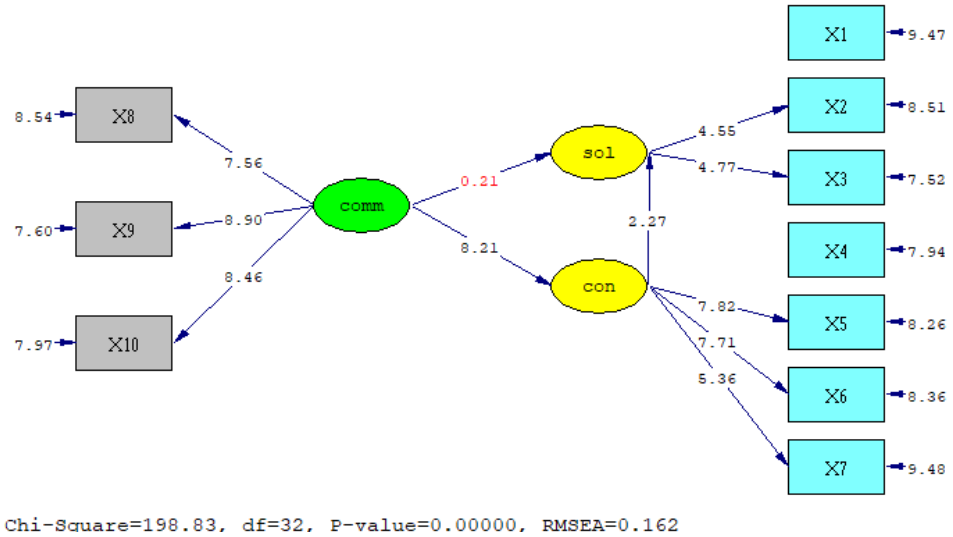

Figure 2: Basic Model T-Values

Based on Figure 1 and Figure 2, we were calculate the validity of each indicator variable and the reliability of each latent variable. We were present these summaries in Table 1, Table 2 and Table 3.Validity & Reliability of Problem Solving Ability (Table 1), Validity & Reliability of Mathematics Communication Ability (Table 2), and Validity & Reliability of Math Connection Ability (Table 3).

Table 1: Validity & Reliability of Problem Solving Ability

Indicator	Standardized Loading Factors (SLF)≥ 0.50	Standard Errors	t-value > 1.96	declaration	Reliability (CR)
X1	0.50	0.04	**	Good validity	**0.52**
X2	0.66	0.60	4.55	Good validity	
X3	0.64	0.59	4.77	Good validity	

The Table 1 shows that there were three observed variables from the latent variable of problem solving (ie, X1: understanding problems (identifying problems and making mathematical models)); (X2: solving problems based on mathematical models); (X3: answer the problem)). The problem solving that has passed the validity test, because it has met the requirements, namely the value of loading factors ≥ 0.50 and t-value ≥ 1.96. Also, construct reliability (CR) is 0.52. This is indicating that the reliability test of the problem solving variable produces pretty good values. So, problem solving has good consistency.

Table 2: Validity & Reliability of Mathematics Communication Ability

Indicator	Standardized Loading Factors (SLF)≥ 0.50	Standard Errors	t-value > 1.96	declaration	Reliability (CR)
X8	0.56	0.60	7.56	Good validity	**0.70**
X9	0.65	0.30	8.90	Good validity	
X10	0.62	0.61	8.46	Good validity	

Look at Table 2. These was explain the indicator variables for mathematical communication abilities. The table confirms the validity of the four observed variables (ie, X4: recognizing equivalent representations of the same concept; X5: recognize the relationship of mathematical procedures to a representation to equivalent representation procedures; X6: use and assess the interrelationships between mathematical topics and the interrelationships outside mathematics; and X7: using mathematics in everyday life). These was indicator variables of math communication ablility. The four observed variables are valid. This is in accordance with the provisions that the loading factor value is ≥ 0.50 and t-value ≥ 1.96. For reliability, the value of construct reliability (CR) is 0.70, indicating that the reliability test of the variable mathematical ability produces good values. Thus, mathematical communication abilities have good consistency.

Table 3: Validity & Reliability of Math Connection Ability

Indicator	Standardized Loading Factors (SLF)≥ 0.50	Standard Errors	t-value > 1.96	declaration	Reliability (CR)
X4	0.50	0.79	**	Good validity	**0.62**
X5	0.64	0.71	7.82	Good validity	
X6	0.66	0.68	7.71	Good validity	
X7	0.44	0.81	5.36	Good validity	

The last latent variable is connection math ability (look at Table 3). Based on the table, almost all was valid indicator variables. Becouse the value of loading factor ≥ 0.50, only X7 is <0.50, but each indicator variable has a t-value >1.96. The indicator variables have be good validity, for all.

For construct reliability value (CR) is 0.62, indicating that the reliability test of the connection mathematics ability variable was good values. This also means that connection mathematics abilities have good consistency.

We proceed by testing the hypothesis. This is testing the direct influence between sol variables (i.e. problem solving abilities), con (i.e. mathematical connection abilities) and comm (i.e. mathematical communication skills).The path diagram shows that the t-value for determining the statistical hypothesis test is Ho. The alternative hypothesis is H1: There are a positive direct effect of mathematical communication skills on problem solving abilities. H2: There are a positive direct effect of mathematical connection skills on problem solving abilities. Also, H3: There are a positive direct effect of mathematical communication skills on mathematical connection abilities.

Look at Figure 2. The t-value for the direct influence of the connection math ability on the problem solving ability was 2.27. This shows that t-value = 2.27> 1.96, with a 95% confidence level rejecting Ho. Thus H2 is accepted, which means that there are a positive direct effect the connection math ability on the problem solving ability.

The t value for the direct effect of mathematical communication on mathematical connections abilities was 8.21 (see Figure 2). Means the value of t > 1.96. This shows that Ho was rejected for a 95% confidence level, and H3 is accepted. Thus, there was a positive direct effect of mathematical communication on mathematical connections abilities.

Furthermore, the t-value for the direct effect of mathematical communication on problem solving abilities was t = 0.21. This shows that the direct effect is not significant. Ho is accepted. Sothere was a positive direct effect of mathematical communication on problem solving abilities, but not significantly.

Based on the path diagram (Figure 2), it shows that there are indirect effects of mathematical communication skills on problem solving abilities through mathematical connections. The effect is 0.79. This shows a significant influence.

The results of this study support previous statements, such as (Wahyuningrum & Suryadi, 2014) that in mathematics learning students become mathematical problem solvers and communicate mathematically. The ability to solve mathematical problems is at the core of learning mathematics. Mathematical communication has an important role in learning mathematics, because through mathematical communication students can express, explain, explain, hear which brings students to a deep understanding of mathematics (Paridjo & Waluya, 2017).

According to (Akinmola, 2014), mathematics is an excellent vehicle for the development of one's intellectual competence in logical reasoning, spatial visualization, analysis and abstract thinking. Students develop the ability to count, reason, think and solve problems through learning and applying Mathematics. This confirms that the results of this study are very important. There was a very significant influence on mathematical communication and mathematical connections to problem solving abilities.

4. Conclusion

In conclusion, there was a positive direct influence on mathematical connections to problem solving abilities. Also, there was a positive direct effect of mathematical communication on mathematical connection skills. In addition, there was a positive indirect effect of mathematical communication skills on problem solving abilities through mathematical connection skills. But the direct effect is not significant.

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