

## Research Article

# Structural equation fit test of mathematical connection ability, mathematical reasoning, and mathematics problem-solving ability of junior high school students

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## ABSTRACT

The purpose of this study was to test the compatibility of theoretical and empirical structural equations on the relationship between mathematical connection skills, mathematical reasoning, and mathematical problem-solving abilities of junior high school students. This is an ex-post facto research at SMP N 1 Bengkulu City. The population of this study was 296 people, and the sample was selected through a simple random technique of 100 people. Data collection techniques through tests with three research instruments. The three instruments are a mathematical problem-solving ability test, a mathematical reasoning ability test, and a mathematical connection ability test that have been valid and reliable based on expert tests and field tests. The data was tested using the Lisrel 8.8 application program. The results of the study are the P-valued of 0.05,  $RMSEA \leq 0.08$ ;  $NFI \geq 0.90$ ,  $NNFI \geq 0.90$ ;  $CFI \geq 0.90$ ;  $IFI \geq 0.90$ ;  $RFI \geq 0.90$ ;  $RMR \leq 0.05$ ;  $SRMR \leq 0.05$ ;  $GFI \geq 0.90$ ; and  $0.8 \leq AGFI \leq 0.9$ ; then the fit test for the complete structural equation model is good fit. It means that the theoretical structural equation model is compatible with the empirical structural equation model. Thus, the overall fit test of the model shows a fit model, and it can be concluded that the empirical structural equation model is compatible with the theoretical model.

**Keywords:** Compatibility test; Problem-solving; Mathematical connection; Mathematical reasoning

## 1. INTRODUCTION

Based on the facts obtained when the researchers carried out Internship-2 in August-December 2021 at SMP N 1 Bengkulu City that the math problem-solving ability score of the junior high school students was 34.63 out of a maximum score of 100. This ability was at a low level. The data shows that the students have difficulty understanding the problem, and making a mathematical model of the problem. This results in students not being able to solve the problems given. In several studies it was found that students had difficulty solving mathematical problems, which resulted in low ability in problem-solving (Dwi & Hendikawati (2018); Schoenfeld (2016); Sulianto, Sunardi, Anitah, & Gunarhadi (2020); Bergqvist (2012)). The low ability of students to solve mathematical problems is a result of low mathematical reasoning (Hasanah, Tafrilyanto, & Aini (2019); Zakir (2015); Sulianto et al. (2020); Hasanah et al. (2019)). Several research results found that mathematical problem-solving ability was influenced by students' mathematical connection abilities (Son, Sudirman, & Widodo, (2020); Pambudi, Budayasa, & Lukito (2020); Baiduri, Putri, & Alfani (2020)). There is a direct relationship between mathematical reasoning ability and mathematical connection ability (Hanifah & Karyati, 2019).

Mathematical problems are part of learning mathematics which is very difficult for students. It resulted in students not liking mathematics, especially in solving mathematical problems (Tambychik & Meerah, 2010). Whereas the ability to solve mathematical problems becomes a process that underlies all mathematical concepts and principles. Mathematical problem-solving can be started from contextual problems that help students understand mathematical concepts, principles and skills. Throughout history, problem-solving has been an integral part of mathematics (Posamentier & Krulik, 2009). Problem-solving is one of the most important mathematical skills. Solving problems is the main means of doing in achieving the goals of mathematics, and not just the goal of learning mathematics itself. It is an integral part of mathematics. Students should be given frequent opportunities to formulate, grapple with, and solve complex problems (*National Council of Teachers of Mathematics* (NCTM), 2010).

Problem-solving is an integral part of the mathematics curriculum. It is taught in addition to the arithmetic skills that are indispensable for success in school and in real life thereafter. In fact, problem-solving provides a reason to teach arithmetic skills (Posamentier & Krulik, 2009). Problem-solving competence is the main goal in educational programs in many countries that are members of the PISA (*Program for International Student Assessment*) and OECD (*Organization for Economic Co-operation and Development*) consortiums. (OECD/PISA, 2012). According to the consortium, it states that

the acquisition of an increased level of problem-solving competence provides the basis for future learning, for effective participation in society and for carrying out personal activities. Students must be able to apply what they have learned to new situations. The study of individual problem-solving powers provides a window into students' abilities to use basic thinking and other general cognitive approaches to deal with challenges in life. Therefore, problem-solving ability is one of the indicators of assessment of the performance of high school students in various countries including Indonesia. PISA monitors and compares educational outcomes in terms of reading literacy, mathematical literacy and scientific literacy (OECD/PISA, 2019). PISA math problems include three components, namely content, context and process. Thus, the PISA measurement tool is dominated by contextual problems with the dimensions of content, context and process.

Troubleshooting became the domain of assessment in PISA 2003 (OECD/PISA, 2012). According to the OECD/PISA (2012) report, in some countries 70% of students can solve relatively complex problems, while in other countries less than 5% can do so. In most countries, more than 10% of students cannot solve basic problems. On average in OECD countries, half of students cannot solve problems that are more difficult than basic problems. Patterns of variation within countries in students' problem-solving abilities differed greatly between countries. The pattern of differences within countries between problem-solving skills and domain-related skills (mathematics, reading, science), differed markedly between countries. This should be measured by a good test, namely the test demonstrates knowledge and understanding in science, skills in planning and conducting investigations, and skills in reading, understanding, and responding to various scientific texts, as well as skills in critical thinking and problem-solving (Scheerens et al., 2010).

According to Brehmer (2015), problem-solving is an assessment of individual problem-solving competencies. Collaborative problem-solving skills are skills needed to solve problems as a group member. Problem-solving can be thought of in a number of different ways. First of all, problem-solving can be considered as a teaching topic (Posamentier & Krulik, 2009). This means that problem-solving is a content in the mathematics curriculum that must be taught to children in the same way that multiplication, long division, percent, and so on are taught. Therefore, problem-solving skills are critical to successful work, where individuals are often members of diverse specialist teams working in separate locations. However, significant measurement challenges still hinder the collaborative task of becoming a feature of large-scale international surveys such as PISA (OECD/PISA, 2012).

In mathematics reasoning is increasingly important in mathematics education. It has become part of the school curriculum and the number of empirical studies is growing (Hjelte et al., 2020). However, the results of the study show that in general students still have low mathematical reasoning abilities (Sukirwan et al., 2018). According to the results of the study, students tend to use imitative reasoning, namely students tend to use routine procedures when dealing with reasoning. On the other hand, based on the given mathematical problem, the students' reasoning ability in learning mathematics can be done inductively and deductively (Haji, 2007). The choice of appropriate mathematical strategies and representations often depends on the context in which the mathematical problem arises. Context is widely regarded as an aspect of problem-solving that places additional demands on problem solvers (students) (OECD, 2019). It is an attempt by students to understand problems, create mathematical models and use models to solve mathematically and apply mathematical solutions to real problems. Therefore, problem-solving is an interaction between knowledge in the *body of knowledge* and application processes that use cognitive and affective factors in dealing with a problem (Rohmah & Sutiarso, 2018). Mathematical reasoning is an important topic in mathematics education both in research and in practice (Hjelte et al., 2020). According to him, reasoning is the process of thinking about something to make a decision. Mathematical reasoning is often associated with mathematical proof and the logical process that accompanies it. Reasoning is not limited to logical thinking but can be based on what makes sense to the person giving the logical-reasoning or not.

In addition to problem-solving, mathematical literacy in the 21st century includes mathematical reasoning and some aspects of numerical thinking. The important role of reasoning requires a greater emphasis in understanding what it means for students to be mathematically literate (OECD, 2021). Within the framework of PISA 2021, that mathematics learning aims to improve and develop the role of mathematical connections in everyday life as well as in the context of solving mathematical literacy problems. Students must possess and be able to demonstrate mathematical reasoning skills as part of their problem-solving practice. Mathematical reasoning abilities and mathematical connections are useful for abstracting, idealizing and generalizing a mathematical object. The results can be stored in the *body of knowledge* and can be recalled to solve mathematical problems (Smit, Bachmann, Blum, Birri, & Hess, 2017).

The ability of reasoning and mathematical connection is an important ability for students in solving problems. It is related to imagination and the ability to construct, retrieve and explore internal representations that form the basis for learning mathematics (Sokolowski, 2018). Because, to improve students' mathematical understanding skills, students must be given the opportunity to relate mathematical objects to everyday life (Haji, 2014). The ability to understand mathematics includes problem-solving, mathematical reasoning, and mathematical connections. Mathematical connection ability is a student's ability to connect between mathematical objects, as well as relate to everyday life (Haji & Yumiati, 2018). In the context of solving mathematical problems, mathematical reasoning abilities are used to understand the problem, and through mathematical connections students are able to create mathematical models related to the problem to be solved. With mathematical reasoning and connections, students can solve problems using mathematical models that have been compiled. Finally, students are able to return in the original problem. This shows that mathematical reasoning abilities and mathematical connections are closely related to the problem-solving process faced by students. Thus, problem-solving requires mathematical reasoning and connections. This is in accordance with the NCTM standard, there are five standard mathematical processes, namely problem-solving, reasoning, connection, representation and communication of school mathematics (Midgett & Eddins (2001); Rahmawati, Purwanto, Subanji, Hidayanto, & Anwar (2017)).

Based on the experience that the researcher gained during the Internship-2 at SMP N 1 Bengkulu City, the mathematical reasoning ability and mathematical connection ability were low. For example, when students are asked to provide arguments and proofs about the Pythagorean Theorem, the majority of students are not able to make proofs and arguments. Students also have difficulty when asked to prove and give an argument that the sum of the angles in a triangle is  $180^\circ$ . The two examples show that students' mathematical reasoning abilities are low. In another problem, the junior high school student had difficulty in connecting mathematical objects with real objects in their environment to create mathematical models. For example, students are asked to determine the area of a fish pond in the form of a circle in a triangular land area. The two difficulties, namely mathematical reasoning, and mathematical connections, resulted in students not being able to solve the problem of the area of the fish pond. This fact is in accordance with the results of the study that most students have difficulty making mathematical connections which result in students' difficulties in solving problems (Jailani, Retnawati, Apino, & Santoso, 2020). This shows that there is a relationship between mathematical reasoning abilities, and mathematical connections with mathematical problem-solving abilities.

Various variations of students' difficulties and errors in mathematical reasoning and mathematical connections from students in grades 7 to grade 9. This is in accordance with the results of research that in each class group there is a level of difficulty from the standard processes and principles of school mathematics, and also the standard content varies. from level to level (Midgett & Eddins, 2001). According to Midgett & Eddins, these principles and standards continue the emphasis on previous process standards, add representational standards and explicitly include evidence in reasoning and modified evidence standards. There are threads for the standard, namely numbers and operations, algebra, geometry, measurement, and data and probability analysis that span all class groups.

Other research shows that students who are able to make mathematical connections will be very helpful in connecting objects in mathematics and outside mathematics (Nordheimer, 2011). It is like that by mathematicians from various fields to find a concept or a principle. This illustrates the interdependence of the epistemic and sociological aspects of mathematical connections. These cognitive processes assist teachers and students in learning about mathematical representation and solving mathematical problems. This provides an overview of students' mathematical representations related to contextual problem-solving skills (Yuanita et al., 2018). In learning mathematics, it also seeks to increase problem-solving skills, think critically, logically and increase reasoning and creative thinking (Haji, 2013). Also, the reasoning process through vertical mathematization (Haji, 2012).

Mathematical reasoning is a mathematical process to help students develop logical thinking skills and develop the ability to think more abstractly in evidence-oriented settings (Sundstrom, 2016). It is to develop the ability to construct and write mathematical proofs using standard methods of mathematical proof including direct proof, proof by contradiction, mathematical induction, case analysis, and counterexamples. Mathematical reasoning is to develop the ability to read and understand written mathematical proofs. Develop talent for creative thinking and problem-solving. Also, improve the quality of their communication in mathematics. In addition, mathematical reasoning can improve writing techniques, reading comprehension, and oral communication in mathematics, which leads to mathematical problem-solving.

Problem-solving is an important element for the teaching and learning of mathematics because the utilization of multiple modes of representation will improve the teaching and learning of mathematics (Mainali, 2021). It can also improve students' mathematical connection skills, teachers should be able to do mathematics outside (Haji, Abdullah, Maizora, & Yumiati, 2017). Therefore, mathematical connections and representations are signs or combinations of signs, characters, diagrams, objects, pictures, or graphics, which can be utilized in learning mathematics. There are four modes of representation in the mathematical domain: (1) verbal, (2) graphic (3) algebraic, and (4) numerical. This will be closely related to the problem-solving process and mathematical connections. Mathematical entities can be represented in a variety of ways. This representation can be observed. There are two parts of mathematical representation, internal representation and external representation. External representations that physically exist and can be observed, and internal representations in the form of models, schemas or concepts that are mental or cognitive and cannot be observed directly (Samsuddin & Retnawati, 2018). The results showed that students who studied outdoors experienced an increase in their mathematical connection skills, and these students had higher mathematical connection abilities than conventional students (Haji et al., 2017).

Mathematics is a scientific communication tool that can be related to other sciences and everyday life (Haji, 2012). It is a standard process in school mathematics learning (Haji & Abdullah, 2016). Therefore, mathematics is a system that can be used in solving problems. According to Silver and Cai (Haji, 2011) that students who are able to make mathematical problems will be able to solve higher problems than other students. In solving problems, students must have the ability to connect between entities related to the problem. According to PISA, students work on modeling problem situations, establish regularities, identify mathematical connections between mathematical entities, and make mathematical arguments (OECD, 2021). This is the process of mathematizing students in reasoning, arguing, proving and connecting between objects, both real objects and abstract mathematical objects. The process becomes an integral part of the problem-solving process.

Based on the descriptions and experiences of Internship researchers at SMP N 1 Bengkulu City, mathematical reasoning abilities, mathematical connections are directly related to mathematical problem-solving abilities related to triangles and the Pythagorean Theorem. Thus, mathematical connections become an important part for students in solving mathematical problems. Mathematical problem-solving ability is a cognitive process that can involve physical activity to find a solution to a problem which is measured based on the following indicators: 1) understanding the problem (Y7), 2) compiling a mathematical model (Y8), 3) applying a mathematical model to solve a problem. solve the problem (Y9), and 4) explain the results according to the original problem (Y10) (Polya, 1973)(Polya, 1981)(Brehmer, 2015)(Kyriakides & Gagatsis, 2000)(Bradshaw & Hazell, 2017)(NCTM, 2000).

Mathematical connection ability is the ability to relate various mathematical objects, and between mathematics and things outside mathematics which is measured based on the following indicators: 1) connecting contexts in everyday life and mathematics (Y4); 2) determine the relationship between mathematical objects used in answering questions (Y5); and 3) utilizing the relationship between mathematical objects to answer the given question (Y6) (NCTM, 2000)(Putri & Wutsqa, 2019)(Pambudi et al., 2020)(Hasbi et al., 2019)(Kadir et al., 2020)(Jailani et al., 2020).

Mathematical reasoning ability is a mathematical cognitive process to connect existing data or facts so as to arrive at a conclusion that is measured based on the following indicators: ( 1) propose a conjecture (X1); (2) compiling evidence (X2); (3) giving reasons from the evidentiary steps (X3) (NCTM, 2000)(Sundstrom, 2003)(Nurjanah et al., 2018)(Mueller et al., 2014)(Sukirwan et al., 2018). Based on these studies, theoretically it can be concluded that mathematical reasoning ability is directly related to problem-solving ability. Also, it is directly related to the ability of mathematical connections. Mathematical connection ability is directly related to problem-solving ability. Lastly, mathematical reasoning ability is indirectly related to problem-solving ability through mathematical connection abilities. This together with the indicator variables builds a theoretical structural equation model i.e.  $Y_{pm} = F(X; Y_k)$ , and  $Y_k = F(X)$ . Two the structural equations, namely (1) and (2) are causal relationships between exogenous variables X and endogenous variables Yk and Ypm. The structural equations are as follows:

$$Y_{pm} = P_{ypmx} X + P_{ypmyk} Y_k + P_{yey}; \tag{1}$$

$$Y_k = P_{ykx} X + P_{ykeyk} y_k. \tag{2}$$

These structural equations can be drawn in a theoretical model diagram, see Figure 1.

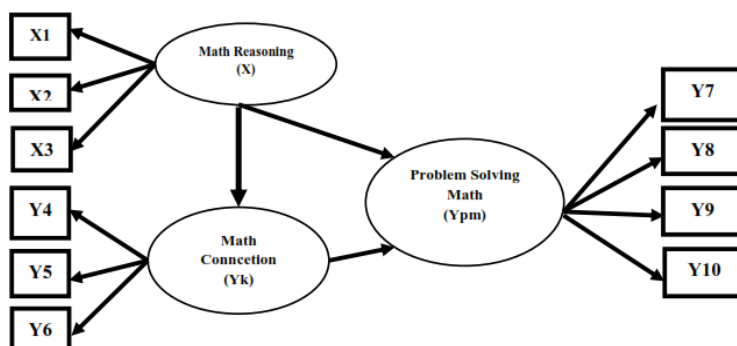


Figure 1. Structural Equation Theoretical Model

Thus, the problem of this research is whether the structural equation of mathematical connection ability, and mathematical reasoning on students' mathematical problem-solving ability **theoretical** fits the empirical model. The aim is to test the compatibility of theoretical structural equations with empirical relationships between mathematical connection skills, mathematical reasoning, and mathematical problem-solving abilities of junior high school students.

## 2. RESEARCH METHOD

This research uses the *ex-post facto method*. The focus is to reveal the causal relationship between the variables of mathematical problem-solving ability, mathematical reasoning and mathematical connections. The design of this research is *The One-Shot Case Study*, in the form of XO, which reveals facts that have occurred (X) through three tests (O), namely tests of mathematical problem-solving abilities, mathematical reasoning and mathematical connections.

The research population is the target of generalization of research results. That is one aspect that must be known before the research is carried out. Based on data from the Deputy Principal for Curriculum Sector, the number of students at SMP Negeri 1 Bengkulu City is 859 people. The details are Class 7 as many as 271, Class 8 as many as 296, and Class 9 as many as 292. By considering the maturity of mathematical competence and not to interfere with the learning process of grade 9 students, the target population reached in this study were all students Class 8 SMP Negeri 1 in Bengkulu City as many as 296 people. The sample was selected through a simple random technique as many as 100 people. The implementation of this research will be carried out in December 2021 to March 2022.

There are three latent variables in this study, one independent variable (exogenous), namely mathematical reasoning ability, and two dependent variables (endogenous), namely the ability of mathematical connections and mathematical problem-solving abilities. Collecting data through tests using three research instruments that have been tested by seven mathematics education experts through panelist tests, and field trials of 30 students. Panelist test provides recommendations that the three instruments are valid and reliable. Experts agree that each item of the problem-solving ability test has a high level of validity with an average Aiken's Validation Index of 0.85, and the coefficient R11 (ICC) =  $0.833 \geq 0.75$ , that means of the instrument is reliable (Ismunarti et al., 2020). Furthermore, each item of the mathematical reasoning ability test has a high level of validity with the average Aiken's Validation Index is 0.99 and the coefficient R11 (ICC) = 0.833, which means that the instrument of mathematical reasoning ability is reliable. The final panelist test is that each item of the mathematical connection ability test has a high level of validity with an average Aiken's Validation Index of 0.97 and R11 (ICC) = 0.965, which means that the expert agrees that the instrument of mathematical reasoning ability is valid and reliable.

Based on field trials on three research instruments, it was found that all problem-solving ability test items were valid with a validity level of 1a = 0.667; item 1b = 0.823; item 1c = 0.789; item 1d = 0.821; item 2a = 0.673; item 2b = 0.754; item 2c = 0.743; and item 2d = 0.676 with Cronbach's Alpha reliability level is 0.780. The results show that the level of validity and reliability of the mathematical problem-solving ability test instrument is high. Furthermore, that all test items are valid, with a level of validity of items 1a = 0.824; item 1b = 0.925; item 1c = 0.835; item 1d = 0.770; item 1e = 0.758; item 1f = 0.900; item 1g = 0.823; item 2a = 0.883; item 2b = 0.877; and item 2c = 0.817, with Cronbach's Alpha reliability level is 0.783. The results show that the level of validity and reliability of the mathematical reasoning ability test instrument is high. The result of the last instrument trial is that all the test items are valid. with item validity level 1 = 0.833; item 2 = 0.835; item 3 = 0.610; item 4 = 0.665; item 5 = 0.724; and item 6 = 0.665, and the reliability level of Cronbach's Alpha is 0.781. The results show that the level of validity and reliability of the mathematical connection ability test instrument is high. The two tests result that the three research instruments have a high level of validity and reliability. The research data were analyzed through inferential statistics path analysis and *structural equation modeling* (SEM). This is an analytical tool to test the compatibility of two structural equations namely  $Y_{pm} = F(X; Y_k)$ , and  $Y_k = F(X)$ . Two Theoretical structural equation is a causal relationship between the exogenous variables X and the endogenous variables Yk and Ypm. Structural equations  $Y_{pm} = P_{y_{pm}x} X + P_{y_{pm}y_k} Y_k + P_{y_{pm}y}$ ;  $Y_k = P_{y_kx} X + P_{y_ky} Y$ . That is the basis for dividing the sub-sub-structure in question. Substructural-1 for the equation:  $Y_{pm} = P_{y_{pm}x} X + P_{y_{pm}y_k} Y_k + P_{y_{pm}y}$ ; and Substructural-2 for the equation:  $Y_k = P_{y_kx} X + P_{y_ky} Y$  (\*).

### 3. RESULTS AND DISCUSSION

This study uses path analysis in the structural equation model (see (\*) ). This is used to determine the suitability of the theoretical structural equation model that has been developed previously (see equations (1), (2) and Figure 1). The measurement results also become to determine the level of reliability and validity, and construct structural equation models diagram of the relationship between latent variables, indicator variables and represents unexplained variances.

The research data were analyzed using the Lisrel 8.8 application, obtained a complete structural model (Figure 2 and Figure 3) with the observed variables and their outputs. A structural equation of a theoretical model is said to fit the empirical model if  $\chi^2$  small with P-value 0.05; RMSEA 0.08; NFI 0.90; NNFI 0.90, CFI 0.90; IFI 0.90; RFI 0.90; RMR 0.05; SRMR 0.05; GFI 0.90; and AGFI 0.9 (or AGFI meets marginal fit) ( *model fit (\*\*)* ). Based on the *output* of data analysis using the Lisrel 8.8 tool, the complete structural equation model fit test is presented in Table 1. This is to test the model overall empirical structural equation.

**Table 1.** Overall Model Fit Test Results

Whole	Benchmark Value for Model Fit	Model Fit to Epiric Data
$\chi^2 = 14.85$ , P-value = 0.127	P-value $\geq 0,05$	Good Fit
RMSEA = 0.021	$\leq 0,08$	Good Fit
NFI = 0.93	$\geq 0,90$	Good Fit
NNFI = 0.98	$\geq 0,90$	Good Fit
CFI = 0.95	$\geq 0,90$	Good Fit
IFI = 0.95	$\geq 0,90$	Good Fit
RFI = 0.97	$\geq 0,90$	Good Fit
RMR = 0.032	$\leq 0,05$	Good Fit
SRMR = 0.045	$\leq 0,05$	Good Fit
GFI = 0.95	$\geq 0,90$	Good Fit
AGFI = 0.83	$0,8 \leq AGFI < 0,9$	Marginal Fit

Based on Table 1, it can be seen that  $\chi^2 = 14.85$ , P-value = 0.127  $\geq 0.05$  means *good fit*. RMSEA = 0.021  $\leq 0.08$ ; means *good fit*. NFI = 0.93  $\geq 0.90$  means *good fit*. NNFI = 0.98  $\geq 0.90$  *good Fft*. CFI = 0.95  $\geq 0.90$  *good fit*. IFI = 0.95  $\geq 0.90$  *good fit*. RFI = 0.97  $\geq 0.90$  *good fit*. RMR = 0.032  $\leq 0.05$  *good fit* SRMR = 0.045  $\leq 0.05$  *good fit*. GFI = 0.95  $\geq 0.90$  *good fit*. Finally,  $0.8 \leq AGFI = 0.83 \leq 0.9$  which means *marginal fit*. This shows that the fit test of the complete structural equation model is suitable. It also means that the theoretical structural equation model is compatible with the empirical structural equation model. Thus, the overall fit test of the model shows *the fit model*, and it can be concluded that the empirical structural equation model can be used as the basis for data analysis in answering the problem of this research.

Research data from the measurement results of three latent variables, namely mathematical problem-solving ability (PMASALAH), mathematical reasoning ability (NALAR), and mathematical connection ability (KONEKSI). Each of these latent variables has several observed variables as measurable indicator variables. Mathematical problem-solving ability is measured through four indicator variables, namely: 1) understanding the problem (Y7), 2) developing a mathematical model (Y8), 3) applying a mathematical model to solve the problem (Y9), and 4) explaining the results according to the original problem. (Y10). Mathematical connection ability is measured through three indicators, namely (a) connecting contexts in everyday life and mathematics (Y4); (b) determine the relationship between mathematical objects used in answering questions (Y5); and (c) utilizing the relationship between mathematical objects to answer the given questions (Y6). Meanwhile, the ability of mathematical reasoning is measured through three indicators as follows: submitting conjectures (X1); compiling evidence (X2); give the reasons for the proof steps (X3).

There are two substructural path equations for the empirical structural model. The structural empirical equation for Substructure-1 is obtained by equation (3):

$$Y_{pm} = 0.389X + 0.603Y_k + 0.238\epsilon_{ypm}; \tag{3}$$

equality empirical (4) is for Substructure- 2:

$$Y_k = 0.912X + 0.409\epsilon_{yk}. \tag{4}$$

Equation (3) and (4) is an empirical structural equation fit model that matches the theoretical structural equation.

Based on the results of data analysis using Lisrel 8.8, presented in the diagram of the structural equation model for the Standardized Solutions of the standard model (see Figure 2 ).

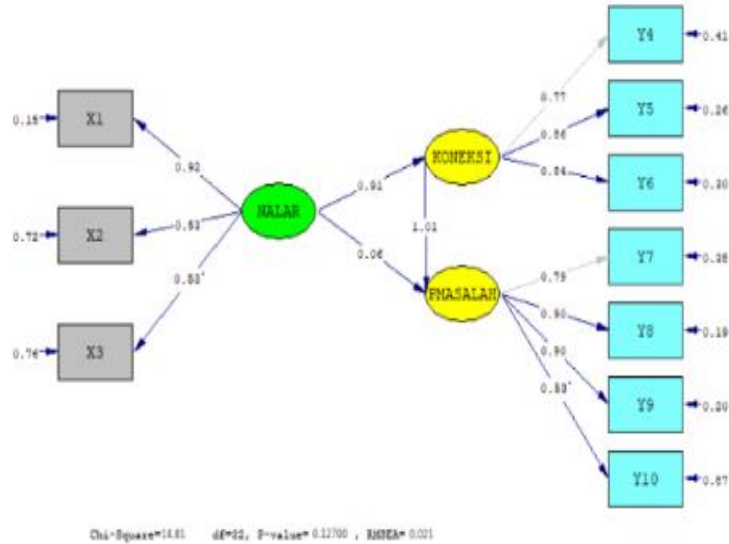


Figure 2. Standardized Solutions of standard model

The output of data analysis using the Lisrel 8.8 application also obtained a *T-value model diagram* of the structural equation model (see Figure 3 ). This chart is to complete the standard solution diagram used to determine the level of validity of each indicator of the latent variable, and the reliability of the latent variable measuring instrument. For the standard solution model, each indicator variable is said to be valid if the loading factor value 0.50 and t-value 1.96 (based on the T-value diagram of the basic model). Meanwhile, to determine the level of reliability of the latent variable measuring instrument provided that the reliability of the latent variable measuring instrument is reliable if *construct reliability ( CR )* 0.70 and the value of *variance extracted ( VE )* 0.50. The formula for calculating CR and VE is as follows:

(Wijayanto, 2008)

Information:

CR = Consistency of a measurement

VE = Total variance in the indicator variable (manifest) that can be explained by the latent variable.

SLF = Standard loading factor of each indicator

e = error of each indicator.

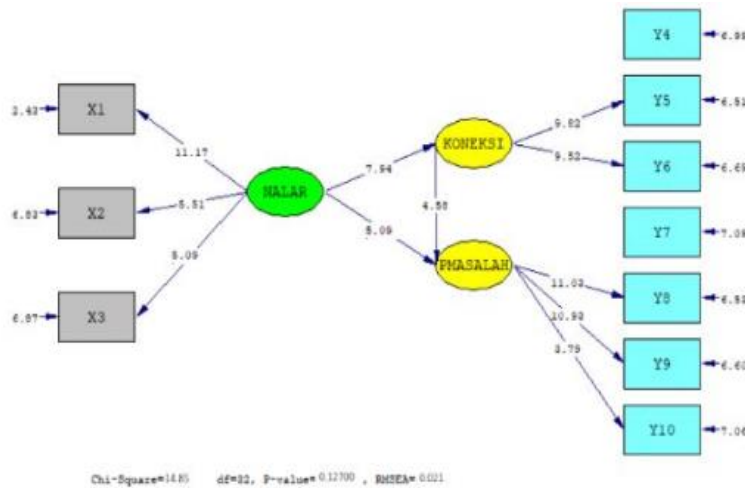


Figure 3. T -value model

Based on **Figure 2** and **Figure 3**, it is determined the level of the validity of each indicator variable and the reliability of each latent variable. A summary of the level of validity and reliability for the mathematical reasoning ability test is presented in Table 2.

**Table 2.** Validity & Reliability Mathematical Reasoning Ability

Indicator	Standardized Loading Factors (SLF) ≥ 0.50	Standard Errors	t-value > 1.96	Validity Description	Reliability		Reliability Description
					CR 0.70	VE 0.50	
X1	0.92	0.15	11.17	Good Validity			Reliable
X2	0.53	0.72	5.51	Good Validity	0.71	0.56	Reliable
X3	0.53	0.76	5.09	Good Validity			Reliable

**Table 2** shows that there are three variables observed from the latent variables of mathematical reasoning ability X1, X2 and X3, each of which has a good level of validity. Test the validity of each indicator is met because the value of *loading factor* 0.50 and t-value 1.96. Meanwhile, for the level of reliability of the measuring instrument for the variable of mathematical reasoning ability, it is obtained that CR = 0.71 > 0.70 and VE = 0.56 > 0.50 which means that the level of reliability variable mathematical reasoning ability is very good. So, the instrument of mathematical reasoning ability has good consistency. Furthermore, the level of validity and reliability for the mathematical connection ability test is presented, presented in **Table 3**.

**Table 3.** Validity & Reliability Math Connection Ability

Indicator	Standardized Loading Factors (SLF) ≥ 0.50	Standard Errors	t-value > 1.96	Validity Description	Reliability		Reliability Description
					CR 0.70	VE 0.50	
Y4	0.77	0.41	--	Good Validity			Reliable
Y5	0.86	0.26	9.82	Good Validity	0.86	0.68	Reliable
Y6	0.84	0.30	9.52	Good Validity			Reliable

Based on **Table 3**, explain that indicator variable for mathematical connection ability has good validity. It is shown that the three observed variables (Y4, Y5 and Y6) have a loading factor value of 0.50 and a t-value of 1.96. It means that each indicator variable Y4, Y5 and Y6 has a good level of validity. For latent reliability, mathematical connection ability was determined by construct reliability value (CR = 0.86 > 0.70) and VE = 0.68 > 0.50. This shows that the reliability test of the mathematical connection ability variable produces a good score. Thus, the mathematical connection ability research instrument has good consistency. Next is the analysis for the variables of mathematical problem-solving ability (see **Table 4**).

**Table 4.** Validity & Reliability Math Problem-solving Ability

Indicator	Standardized Loading Factors (SLF) ≥ 0.50	Standard Errors	t-value > 1.96	Validity Description	Reliability		Reliability Description
					CR 0.70	VE 0.50	
Y7	0.79	0.70	--	Good Validity			Reliable
Y8	0.90	0.61	11.02	Good Validity	0.80	0.51	Reliable
Y9	0.90	0.52	10.92	Good Validity			Reliable
Y10	0.53	0.56	2.79	Good Validity			Reliable

Another endogenous latent variable is mathematical problem-solving ability (see **Table 4**). Based on the table, all are indicator variables (Y7-Y10 has a loading factor value of 0.50 and each indicator variable from it has a t-value > 1.96. Thus, each indicator variable of mathematical problem-solving ability has a high level of good validity. For the construct of the reliability value (CR) of the latent variable of mathematical problem-solving ability is 0.80 > 0.70 and VE = 0.51 > 0.50. It shows that the reliability test of the variable of mathematical problem-solving ability is good. So, the instrument for measuring the latent variable of mathematical problem-solving ability has good consistency.

Based on the description of the results of the analysis of the suitability of the structural equation model, test the validity of each indicator of each latent variable, and test the reliability of measuring instruments for each latent variable, then summarized in **Table 5**.

**Table 5.** Summary of Goodness of Fit Test Results, Validity and Reliability

Latent Variable	Indicator Variables	Validity	Reliability	Model Fit Conclusion
Mathematical Reasoning Ability	X1	valid	reliable	Since the P-valued of $\chi^2_{hitung}$ 0.05, RMSEA 0.08; NFI 0.90, NNFI 0.90; CFI 0.90; IFI 0.90; RFI = 0.90; RMR 0.05; SRMR 0.05; GFI 0.90; and $0.8 \leq AGFI = 0.83 \leq 0.9$ ; then the fit test for the complete structural equation model is <i>good fit</i> . It means that the theoretical structural equation model is compatible (see (**)) with the empirical structural equation model. Thus, the overall fit of the model shows the fit. model (see (**)), and it can be concluded that the empirical structural equation model can be used as the basis for data analysis in answering this research problem.
	X2	valid		
	X3	valid		
Math Connection Ability	Y4	valid	reliable	
	Y5	valid		
	Y6	valid		
Math Problem Solving Ability	Y7	valid	reliable	
	Y8	valid		
	Y9	valid		
	Y10	valid		

Based on **Table 5**, test the suitability of the structural equation model, test the validity of each indicator of each latent variable, and test the reliability of measuring instruments for each latent variable that meets all of the test criteria, then the data analysis can be continued with hypothesis testing.

The results of this study provide an illustration that the empirical structural equation is in accordance with the theory. The latent variables of mathematical reasoning ability, mathematical connection ability, and problem solving ability are causally related according to the structural equation model. This supports the results of previous studies such as the research of Jailani, Retnawati, Apino, & Santoso (2020) that mathematical connection ability is directly related to mathematical problem solving ability. Similar results were also found by Hasbi et al. (2019) ; Kadir, Rochmad, & Junaedi (2020) ; Haji & Yumiati (2018) ; Haji et al. (2017) ; Baiduri, Putri, & Alfani (2020) ; Pambudi, Budayasa, & Lukito (2020) ; Putri & Wutsqa (2019) ; and Son, Sudirman, & Widodo (2020) , all of whom showed that mathematical connection skills are directly related to mathematical problem solving abilities.

The structural equation model of this study is also supported by the research of Tisngati & Genarsih (2021) ; Sandy, Inganah, & Jamil (2019) ; Masfinatin, Murtafiah, & Maharani (2020) ; Hasanah, Tafrilyanto, & Aini (2019) ; Lestari (2019) ; Zakir (2015) ; and Helviyana, Susanti, Indaryanti, Sari, & Simarmata (2020) , which results in mutually equivalent statements. Their results are that mathematical reasoning ability is closely related to mathematical problem-solving ability.

Another path in the empirical structural equation model of this research is also supported by the results of research by Hanifah & Karyati (2019) ; Mueller, Yankelewitz, & Maher, (2014) ; Astari & Marsigit (2019) ; and Siregar & Siagian (2019) , which similarly resulted in the conclusion that reasoning ability is directly related to mathematical connection ability. Other studies also provide supporting conclusions such as Haji (2007) ; and Hodiyanto (2017) that there is a significant positive relationship between mathematical problem solving ability and mathematical connection ability with mathematics learning achievement. Thus it is increasingly convincing that the complete structural equation is a *good fit*. It means that the theoretical structural equation model is compatible with the empirical structural equation model.

#### 4. CONCLUSION

The suitability test of the structural equation model is a requirement for this research data to be tested further. The test results show that the overall fit of the model shows a *model fit*. The conclusion of this research is that the empirical structural equation model can be used as the basis for data analysis in answering research problems.

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## AUTHOR'S CONTRIBUTIONS

The authors are discussed the results and contributed to from the start to final manuscript.

## CONFLICT OF INTEREST

There are no conflicts of interest declared by the author.

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