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# Students' mathematical conceptual understanding and its relation to the mathematical communication skills

**Joko Krismanto Harianja, Sarah Lorin Hernadi, Isabela Indah**
Master of Educational Technology, Faculty of Education, Universitas Pelita Harapan, Jakarta, Indonesia
E-mail: joko.harianja@outlook.co.id

***ABSTRACT***

*This research was basically conducted to improve students' understanding of mathematical concepts and mathematical communication skills both verbally and non-verbally using the Rally Coach learning method. In addition, the main purpose of this study is to examine and analyze the relationship between students' understanding mathematical concepts and mathematical communication. Therefore, the authors first design instruments to measure students' understanding of mathematical concepts and mathematical communication skills that have been adapted to indicators. This study is based on correlational research method. The instrument was tested to see its validity and reliability using the Cronbach Alpha formula. The results show that the application of the Rally Coach learning model has a positive influence in improving students' understanding of mathematical concepts and mathematical communication. The results of the analysis by statistical testing with Pearson correlation show that there is a relationship between understanding mathematical conception and mathematical communication skills, but the relationship is not so strong. This can be seen from observations made by authors, some students are able to understand mathematical problems, but are not fully able to communicate verbally.*

*Keywords: mathematical communication; mathematical conceptual understanding; Pearson correlation; rally coach; validity and reliability test.*

## INTRODUCTION

Mathematics is a science that becomes an object of systematic examination of physical measurements, shapes, signs, numbers, and the relationships between them. In addition, mathematics is a universal science that underlies the development of modern technology in various disciplines and is able to develop the power of human thought (Arfah, 2018). So, it is very important to study mathematics at every level of education.

Mathematics as one of the fields in science which plays an important role in improving some soft skills such as thinking skills and communication skills. Teaching and learning mathematics is not merely about imparting knowledge but it can form positive attitudes on students (Triwibowo, Pujiastuti, & Suparsih, 2018). Mathematical processes that support mathematics learning are problem solving, reasoning and proof, reflection, selection of computational tools and strategies, linking, representation, and communication (Harianja, 2019).

The mathematical process can be seen as a process of students acquiring and applying mathematical knowledge and skills. These processes are interconnected. Thus, communication skills are an important process in learning mathematics (Wear & Indrawati, 2017). Learning mathematics allows the students to develop specific mathematical abilities in solving daily problems or communicate ideas by using symbols, tables, and diagrams (Nandau, Syaban, & Retnaningrum, 2019).

Mathematical communication skills really need to be developed among students. Mathematical learning activities in the classroom must be able to help students communicate mathematical ideas through five aspects of communication, namely representing, listening, reading, discussing and writing. Furthermore, there are at least two important reasons,

why communication in mathematics learning needs to be developed among students (Umar, 2012). First, mathematics as language, means that mathematics is not just a tool for thinking tools to find patterns, solve problems or draw conclusions, but mathematics is also an invaluable tool for communicating a variety of ideas clearly, precisely, and succinctly. Second, mathematics as social activity which means as a vehicle for interaction between students, and as a means of communication between teacher and students (Umar, 2012). Through mathematical communication learners can convey ideas and clarify mathematical understanding both verbally and in writing (Hodiyanto, 2017).

Conventional teaching methods that are commonly used in teaching mathematics in Indonesia, do not give opportunities to students to express and communicate their ideas. The learning process in mathematics is still dominated by conventional learning methods and without using media (Febriyanto, Haryanti, & Komalasari, 2018). Conventional teaching refers to a teaching method involving instructors and the students interacting in a face-to-face manner in the classroom. These instructors initiate discussions in the classroom, and focus exclusively on knowing content in textbooks and notes. Students receive the information passively and reiterate the information memorized in the exams (Li, 2016). It gave rise to a passive learning situation for students. Even students are not able to redefine the content of material that has been learned in their own language. It also gave rise to the paradigm that mathematics is a subject that is difficult to understand and boring (Febriyanto et al., 2018).

The teachers have tried their best to transfer their knowledge without considering what soft skills that actually could be developed through mathematics (Febriyanto et al., 2018). Even though the government of Indonesia through the ministry of education has launched the new rules and constitutional regarding the competencies needed to develop on learners in mathematics, but it has not been running well yet. Some teachers still keep their traditional culture during teaching and learning process (Markawi, 2015). Knowing the mathematical methods and concepts are really good, but those are not enough. Learning mathematics should give positive impacts on learners that could be applied in their daily life activities outside the school time and even in the future (Kartika, 2018).

The aim of this study is actually to analyze and obtain some meaningful information about the relationship of mathematical conceptual understanding with the mathematical communication skills. The authors were willingly to know if there was a relationship between the mathematical communication skills improvement with good mathematical conceptual understanding on learners. This study is also to encourage learners to develop their understanding on mathematical concepts, develop their mathematical communication skills, and motive teachers in creating good learning environments that enhance learners' interest in learning mathematics.

Mathematics consists of various concepts arranged hierarchically, so understanding mathematical concepts become very important. Learning concepts is the most fundamental thing in the process of learning mathematics, therefore a teacher in teaching a concept must refer to a goal that must be achieved (Fitria, Kartasasmita, & Supianti, 2019). Learners' mathematical conceptual understanding according to National Council of Teachers of Mathematics (NCTM) can be seen from the ability of students in several criteria, such as defining concepts verbally and in writing, making examples, using symbols to represent a concept, changing a form of representation to other forms, recognize various meanings and interpretations of concepts, identify the properties of a concept and recognize the conditions that determine a concept, and compare and differentiate concepts (Juniantari, Pujawan, & Widhiasih, 2018). Mathematical conceptual understanding is the ability to understand abstract ideas and basic objects learned by learners, associated with mathematical notations

and symbols relevant to mathematical ideas and then combine them into a series of logical reasoning (Romadon & Mahmudi, 2019).

Mathematical communication skills are one of the basic abilities that learners and teachers must have in the learning process (Nandau et al., 2019). When students are challenged to think about mathematics and communicate the results of their thoughts verbally or in written form, it means they are learning to explain and convince what is in their minds. Through mathematics learning, students are expected to be able to communicate ideas with symbols, tables, diagrams, or other media to clarify the situation or problem (Kuslinar, Awaludin, & Arapu, 2019).

Communication skills in mathematics help teachers understand learners' abilities in interpreting various forms of their mathematical conceptual understanding. Thus, through effective communication, it is hoped that learning objectives can be achieved (Setiaji, Kuswanto, & Suherman, 2019). It is expected that teachers can develop students' mathematical communication skills both inside and outside the classroom, so students can communicate accurately, precisely, systematically, and efficiently in learning, especially in learning mathematics. In addition to communication skills, to obtain optimal learning achievement in mathematics, learners must be able to be independent in learning (Santi, Swari, & Kartono, 2019) .

Mathematics learning does not happen in a vacuum. For effective mathematics learning, supportive school and classroom learning environment is crucial. Therefore, to encourage the learners developing their mathematical conceptual understanding and mathematical communication skills, teachers are expected to be creative in creating an interesting learning environment by implementing certain constructive learning model (Harianja, 2019). In the learning process, learners must have the opportunity to express their ideas that are being thought about. When learners are allowed to convey strategies and arguments, and present ideas both verbally and in writing, they will be challenged to understand more deeply the concepts being studied. In other words, the teacher must be able to communicate mathematics with students. Experts suggest that effective teachers work to improve learners' communication skills such as speaking, listening, overcoming verbal communication barriers, understanding non-verbal communication, and being able to solve conflicts constructively. Active listening and empathy can be helpful responses when students bring problems to the teachers. The teacher must reflect learners about what they have heard from the explanation.

In this study, the Rally Coach learning model is used as a treatment to improve students' mathematical understanding and mathematical communication skills. Rally Coach provides students with an opportunity to coach their peers through problems and questions. Students are paired together: one is partner A, and one is partner B. The students solve problems or answer questions aloud in pairs. Students take turns solving one of their problems or questions aloud, so their partner coaches can listen to their thinking and process. As Partner B listens, they check for accuracy, clarify any misconceptions, and "coach" Partner A as needed. The students switch roles when the problem is correct. This strategy supports student collaboration, communication, and mastery in the classroom (Marlina, Soetjipto, & Hadi, 2016).

The Principles and standards for school mathematics (National Council of Teachers of Mathematics [NCTM] , 2000) also highlighted the importance of communication as an important part of mathematics in education. Through communication, an idea becomes an object of reflection, refinement, discussion, and change, and this is the process that helps

build meaning and determine ideas, and make those ideas generally applicable. Emphasizing the importance of communication in mathematics is also outlined in the 2013 curriculum. The formulation of competency attitudes, knowledge, and skills used in the 2013 curriculum emphasizes the importance of creativity and communication.

Mathematical communication skills are the ability to communicate which includes usage activities writing, listening, analyzing, interpreting, and evaluating ideas, symbols, terms and mathematical information observed through the process of listening, presenting, and discussing. Thus, through communication skills students can better understand about mathematics so that the ability to communicate ideas verbally and in writing is very important to be improved (Rufaidah, 2019). Danaryanti (2015) states that mathematical communication skills are the ability of students in terms of explaining an algorithm and unique ways to solve problems, the ability of students to construct and explain presentations of real-world phenomena graphically, words or sentences, physical equations, tables and presentations or students' abilities to provide guesses about geometric drawings. Mathematical communication is a way for students to communicate ideas, strategies and mathematical solutions both in writing and orally (Danaryanti & Lestari, 2018).

The indicators of students' ability in mathematical communication in mathematics learning according to NCTM (2000): 1) The ability to express mathematical ideas through oral, written, and demonstrate and visualize them; 2) The ability to understand, interpret, and evaluate mathematical ideas both verbally and other visual forms; 3) The ability to use mathematical terms, notations, and structures to present ideas, describe relationships and models of situations.

From the description above, it can be seen that verbal and non-verbal mathematical communication is not specifically distinguished. Indicators of mathematical communication skills according to NCTM include the ability of students to explain ideas or ideas verbally. In this study, verbal communication skills were observed when students tried to discuss mathematical ideas or ideas when solving or solving mathematical problems. This can be seen through direct observation when the Rally Coach learning model is being implemented in learning activities.

## RESEARCH METHODOLOGY

This study applied quantitative method as the methodology based on correlational research. The subject of this study was the grade XI senior high school students as the population from a XYZ school in Bogor, West Java. The XYZ school is an international school which implements International Baccalaureate Diploma Program (IBDP) curriculum by taking a population of grade XI students with 60 students consisting of 3 major classes, XI A, XI B and XI C. Purposive sampling technique was used in this research and the authors decided to take grade XI B as the sample. As for the consideration by choosing class XI B because not a few numbers of students in grade XI B with low achievement in mathematics and low mathematical communication skills as well. The average of mathematics result in this class is lower compared to other grade XI classes. This also indicates that students' understanding of mathematics is still low. This class consists of 20 students with a composition seven female students and thirteen male students. The object of this study is the mathematical conceptual understanding and mathematical communication skills on students.

Firstly, based on the general purpose of this research is to develop students' mathematical conceptual understanding and mathematical communication skill by implementing Rally

Coach as the learning method. This treatment was given for four consecutive weeks. During this time, direct observations were continued to be made to see the development of students in understanding mathematical concepts and mathematical communication skills. Every change in learning activities have been recorded for further analysis to be evaluated.

The data or information which have been used in this study was actually collected from the students' test results. The research instrument is a tool used in gathering research data. In this quantitative research, data collection tools or research instruments generally used by researchers to be developed from the description of research variables which are from theories that will be tested. For this reason, before the research instrument developed is used to collect data on real objects or respondents, the instrument should be tested for validity and reliability. Authors' understanding of the validity and reliability of instruments is an absolute prerequisite for quantitative research.

The test instrument given to the students was actually the instrument which has been created by the authors to measure their mathematical conceptual understanding and mathematical communication skills. This test instrument consisted of trigonometric equations and functions questions. Trigonometric equations and functions were chosen because when this study was conducted, the learners were learning this topic. Each question in the test instrument used to measure students' mathematical conceptual understanding and mathematical communication skills was based on the indicators of these two competencies. The instrument which was used by the research in this study consisted of 14 structured questions. Before the test was given to grade XI B students, it was given first to grade XI A students to measure its validity and reliability. Cronbach Alpha formula was used to measure the reliability of the instrument.

In compiling the test instrument, it began with the compilation of the questions, followed by feeding questions and alternative key answers for each item. To provide an objective assessment, the scoring criteria for the test questions about the ability of mathematical conceptual understanding were guided by scoring rubrics.

## RESULT AND DISCUSSION

Based on the Rally Coach is implemented in learning activities, it can be clearly known that the understanding of mathematical concepts and mathematical communication skills of students has increased significantly. This can be seen from the increase in learning outcomes through the value obtained after treatment is given. There is a significant difference between pre-test scores and student post-tests. Evaluation of student learning outcomes to determine the value of the two variables is based on predetermined indicators.

The results of this study to improve mathematical communication skills and understanding of mathematical concepts are supported by several studies that have been conducted by previous researchers related to the application of various learning models. For example, the improvement of students' mathematical communication skills has been done by applying the Think Pair Share learning model. Cooperative learning type Think Pair Share has the feasibility to be developed in the learning process especially to improve mathematical communication skills and foster motivation in students' mathematics learning (Wulandari, 2016). The success of Think Pair Share cooperative learning activities is very dependent on the ability of the teacher to involve the active role of students as a whole. Therefore, efforts to optimize student involvement starts from the planning process through to evaluation (Wulandari, 2016)

In addition, the results of students' mathematical communication skills improved after using the Student Teams Achievement Division (STAD) cooperative learning model (Noor & Husna, 2017). The STAD type of cooperative learning model is one type of cooperative that emphasizes the existence of activities and interactions among students to motivate each other and help each other in mastering subject matter in order to achieve maximum achievement (Noor & Husna, 2017).

Another example that has been done to improve students' mathematical communication skills is by using a jigsaw cooperative learning model for students of class VII-1 SMP N 6 Ternate City. Mathematical communication skills of VII-1 grade students of SMP N 6 Ternate after the implementation of the jigsaw cooperative learning model showed that there were 8 students who received very good criteria, 2 students of good criteria, 2 students of sufficient criteria, 6 students of less criteria and 3 students of very criteria less (Saputra, Angkotasan, & Bani, 2017).

Mathematical communication skills of students after the implementation of a jigsaw cooperative learning model with an average value of 21 students' posttest is 68.1 shows students are able to understand and solve questions relating to the addition and reduction of algebraic forms with indicators of the ability to develop understanding with mathematical ideas into rules, the ability to explain ideas and situations in writing and the ability to express mathematical ideas in writing (Saputra et al., 2017)

Research that has been conducted using the Rally Coach cooperative learning model also shows an increase in students' mathematical communication. By applying the Rally Coach learning model, students not only develop mathematical communication skills non-verbally, namely by explaining in detail the process of solving mathematical problems with appropriate steps in writing in accordance with mathematical communication indicators. However, in explaining verbally to fellow students in a group where each student gets the opportunity to explain to his group friends any ideas or ideas in solving mathematical problems.

From the acquisition data, it can be seen that the number of students who have had the ability to explain in writing each process and the steps that must be used to find solutions or solutions to the problem equation and function being solved has increased the number of seven students (35%) to eleven students (55%). There was an increase of 5% from the previous amount. One of the factors that caused the drastic increase has not yet occurred because students are not yet familiar with the Rally Coach learning model. This increase is seen from the way students answer the story questions. Students are able to translate problems in the form of stories into appropriate mathematical equations using their own language and the process of answering with a good structure, until reaching the final result. This result also shows that students who answer the given problem have a good understanding of mathematical concepts, specifically the concept of equations and trigonometric functions.

Based on direct observations made by researchers in the classroom, especially when given a Rally Coach learning model, for four consecutive weeks it can be concluded that each student is able to cooperate cooperatively and collaboratively in completing each given mathematics problem. However, during the learning process, based on observations it can be noted that there are still students who find it difficult to explain verbally or verbally the steps in solving the math problems given. There are students who are able to do the problem well in writing, but still lack in explaining it with verbal communication. As described in the previous background, research on mathematical communication aspects looks at improving verbal and verbal mathematical communication. From the observations made, some students still

find that it was difficult to explain the steps used in writing into verbal communication. This may be caused by students not yet accustomed to communicating the process used to get the final result or the solution of a mathematical problem. In fact, it can be said that there are many students who have a fairly good understanding of mathematical concepts, but have difficulty communicating them verbally. Students who are able to communicate mathematical problems in writing, but not in writing, cannot yet be said to have developed their overall mathematical communication skills. This is in accordance with what is explained by Umar in his research which suggests that proper mathematical communication is when students are able to communicate their ideas in an effort to answer contextual problems given by the teacher both verbally and non-verbally, how students participate actively in discussions, negotiations and how students "take responsibility" for their answers to open questions and assignments given by the teacher, clearly require the ability to communicate them (Umar, 2012).

Learning outcomes on the aspects of mathematical communication skills before and after using the Rally Coach learning model statistically have significant differences. In other words, the mathematical communication skills of students taught by the Rally Coach method through cooperative learning are different from students taught by conventional methods.

This is allegedly because in learning with the Rally Coach method students dare to convey ideas or ideas to a group of friends in answering questions given by the teacher. With the Rally Coach method students can discuss and ask each other something that is not yet understood while playing with a group of friends where in this strategic method students are not so stressed in learning.

Through cooperative learning, students are given wider opportunities to be recognized, both in their groups and in learning. Students are more willing to express ideas in their minds because they learn in groups. Each student is free to show their participation in expressing ideas and ideas and ask questions that they do not understand. Students are also free to communicate their opinions classically because in the implementation of cooperative learning students are asked to clarify material that is not yet understood by weak students

Mathematical understanding is closely related to mathematical communication. Students who already have a mathematical understanding ability are required to be able to communicate it, so that their understanding can be utilized by others, by communicating their mathematical ideas to others, students can improve their mathematical understanding. This is similar to the view of Sudjana (Setyaningtyas et al., 2019) hat to improve mathematical conceptual understanding, students do it by expressing mathematical ideas.

Mathematical communication skills of students are described based on the results of communication skills tests that have been given to students. The data obtained shows that the number of students who already have a category of high concept comprehension level is more than the number of students in other categories. The number of students who have a level of communication skills in mathematics is 11 people out of 20 people or proportionately more than 50% of students have a high level of communication skills. But not a few students who still have a low level of communication skills because 9 out of 20 people are still in this category.

After conducting research, researchers obtain data about valuable scientific descriptions of conceptual understanding of mathematics and mathematical communication skills obtained using tests. The correlation test is one of the statistical analysis techniques used to find the relationship between two quantitative variables. The relationship between these

two variables can occur because of a causal relationship or it can also occur by chance alone.

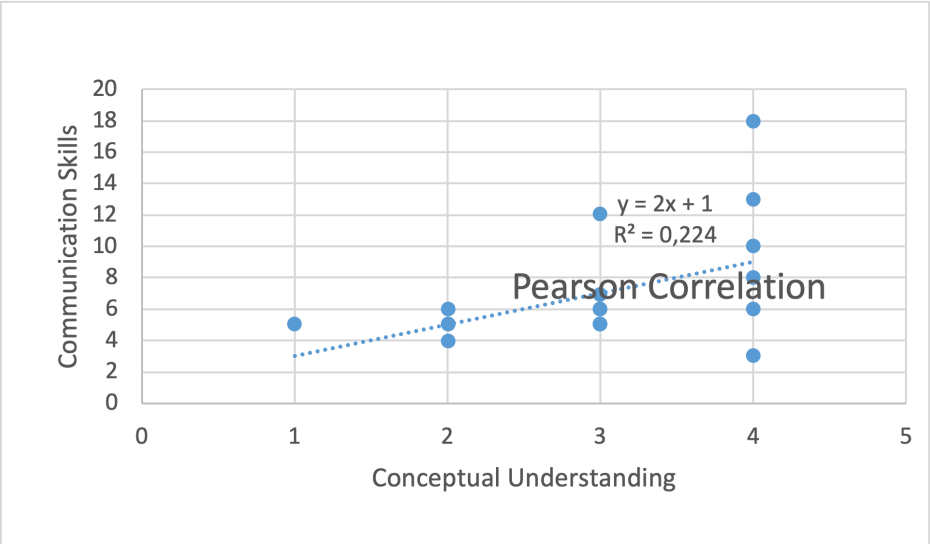


Figure 1. Line of regression using Pearson correlation

In this study, Pearson correlation formulation was used to analyze the relationship between these two variables. From the calculations, the Pearson coefficient obtained was 0.473 with obtained is 0.224. This situation can be seen in figure 1. This illustrates clearly that there is a relationship between mathematical conceptual understanding and mathematical communication skills. Pearson coefficient value of 0.473 states that the relationship between the two variables is weak. The value of 0.244 indicates that the contribution of influence given to the independent variable (mathematical conceptual understanding) to the dependent variable (mathematical communication skills) is 24.4%.

Thus, the hypothesis H0 is accepted and H1 is rejected. Based on the results of the analysis on the output coefficients also obtained a simple regression equation between mathematical conceptual understanding (X) of students' mathematical communication skills (Y) in the form Coefficient b is the coefficient of the regression direction and states the average change in variable Y, for each change in variable X by one unit. Where in the above equation it is known that b is positive, this states that each addition to the value of mathematical conceptual understanding ability then the value of students' mathematical communication skills also increases. If the value of the independent variable (X) is 5, then the regression equation Y = 2 (5) + 1 = 10 + 1 = 11. This figure shows if the average mathematical concept comprehension ability is 5, then the average value of learner's mathematical communication skills equal to 11. Whereas if the independent variable (X) has a value of 0 then it can still be obtained the equation Y = 2 (0) + 1 = 1. From this, it can be interpreted that even though the value or score of learners' mathematical concept understanding ability is 0, the score learners 'mathematical communication skills are still obtained with a score or score of 1. This shows that learners' mathematical communication skills are not only influenced by the ability to understand mathematical concepts but are also influenced by other factors not examined in this study.

The findings in this study indicate a relationship between mathematical communication skills and the ability to understand mathematical concepts of students, although not so great relationship or influence. This is seen in student work. Students have diverse communication and understanding abilities. Some students in each category of mathematical communication skills also have diverse concept understanding abilities. That is to say at every level of mathematical communication skill there are students who have the ability

to understand concepts very low, low, high, and very high. Some students who are able to use concepts well do not have good writing skills but have good oral communication skills. Students who have low communication skills but have high concept understanding skills only complete solutions to the concepts they understand without regard to communication elements. For example, students do not write down information that is known and asked and do not provide additional explanation as a reason in solving problems. This can be seen in figure 2. In this figure, it was given students' work with different results, one is correct and the other one is wrong.

On the other hand, students who have low concept comprehension skills but have high communication skills because they are not able to use concepts well then students can write information that is known and asked from the problem even though students use the wrong concepts in problem solving. However, it gives information in the form of words in the answer. With the diversity of the conceptual comprehensiveness at each level of communication understanding, this reinforces the statistical conclusion that there is a relationship between mathematical communication skills and the ability to understand mathematical concepts in class IX although the relationship is not very strong because there are other unknown factors

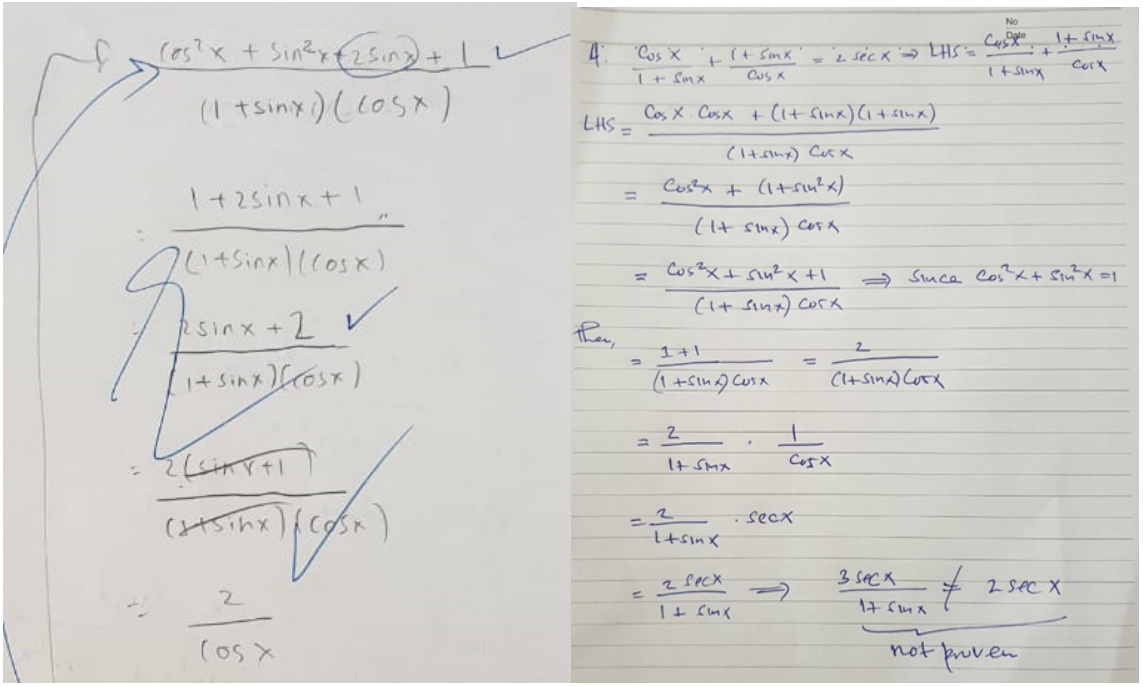


Figure 2. Students' Work in Trigonometric Identities

The picture on the left side shows that the student wrote the correct process in dealing with the trigonometric identities problem. The student tried to write properly step by step even though without writing the information like what student has made on the right side. The picture on the right side shows in the beginning the step is still correct with writing important information by taking the expression on left hand side of the question to be simplified as the expression on the right-hand side. Unfortunately, on the second step in the process, the student miscalculated the multiplication process. So that why after that, the remaining process remains wrong, even though the students have written the very basic identity formula.

From the students' work, we can see that the students have tried to communicate their ideas non-verbally. But since this assignment has been done and discussed in groups by

implementing Rally Coach learning model, the students take turns to explain verbally with theirs partner how they explain the process step by step until obtaining the final answer or the suitable identity.

## CONCLUSION

Based on data processing and discussion of research results related to the research objectives can be obtained conclusions about research that has been conducted using the Rally Coach learning model are as follows: learning mathematics using the Rally Coach approach contributes greatly in improving the ability to understand mathematical concepts and mathematical communication skills of grade XI students on trigonometric equations and functions. Improved mathematical understanding skills in the classroom are caused by learning designed using authentic problems, choosing the right media.

It can be understood that mathematical communication is the level of ability in students in the form of mastery of mathematical concepts, knowledge, attitudes and skills that are realized in the form of mathematics communication skills test scores after the learning process ends. In this study the communication skills obtained by students were limited to the aspects of representation and writing which in administering the test, the indicators considered were students able to explain the completion procedure or how to avoid mistakes.

In this study, based on the validity and reliability test on the test instrument, the researchers can conclude that results on the test instrument was valid and reliable. This statement is stated based on the reliability test result which are 0.84. The reliability tests were performed using the Cronbach Alpha formula. The reliability test results obtained for each test instrument are greater than the minimum value of Cronbach Alpha 0.6.

Regarding the hypothetical test results which has been processed, it can be concluded that there is a relationship between the ability to understand mathematical concepts (mathematical conceptual understanding) with learners' mathematical communication skills. Hypothesis testing results that have been carried out to see how closely the relationship between these two variables using the Pearson correlation test with a Pearson coefficient of 0.473 shows that the relationship between these two variables is not so strong or there is a weak relationship. A value of 0.224 from the test also indicates that students' mathematical understanding ability contributes approximately 22.4%. In other words, there are still other factors that affect students' mathematical communication skills that still need to be researched. As a suggestion for further research, it is hoped that research can be carried out by applying better learning models such as certain cooperative learning models to see whether mathematical communication skills can be improved by increasing mathematical concept understanding skills

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