Development of Rainbow Mathematics Card in TGT Learning Model for Increasing Mathematics Communication Ability

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Abstract

Mathematics communication, which includes writing, drawing, and expressing mathematics, is essential in learning mathematics. The teacher needs to design learning to develop the ability to communicate mathematically. Questions presented in the Rainbow Mathematics Card (RMC) allow participants to be educated to convey the ideas and concepts that become part of developing mathematics communication ability. The study aims to make mathematics communication ability TGT learning with RMC. A type study is a mixed method that is designed and experimented with in subjects research. Data was obtained through test mathematics ability communication before and after learning using a paired t-test. The results showed an enhanced mathematics communication ability through the TGT learning model with RMC.

Abstrak

Komunikasi matematika yang meliputi menulis, menggambar, dan mengekspresikan matematika, sangat penting dalam pembelajaran matematika. Guru perlu merancang pembelajaran untuk mengembangkan kemampuan berkomunikasi matematis. Soal-soal yang disajikan dalam Rainbow Mathematic Card (RMC) memungkinkan peserta dididik untuk menyampaikan ide dan konsep yang menjadi bagian dari pengembangan kemampuan komunikasi matematika. Tujuan penelitian ini untuk tes peningkatan kemampuan matematis melalui pembelajaran TGT dengan RMC. Jenis studi adalah metode campuran yang kemudian dikembangkan dan dieksperimentasikan ke subjek penelitian. Data diperoleh melalui tes kemampuan komunikasi matematis sebelum dan sesudah pembelajaran menggunakan uji t berpasangan. Hasil penelitian menunjukkan peningkatan kemampuan komunikasi matematis melalui pembelajaran TGT dengan RMC.

Keywords: Development; Mathematics Communication Ability; Rainbow Mathematics Card; TGT; Kemampuan Komunikasi Matematika; Kartu Matematika Pelangi, Pengembangan; TGT.

INTRODUCTION

Mathematics is the primary knowledge role in the progress of knowledge and technology. To face challenges more in life and be competitive in the globalization era, Indonesian people must have skills in diverse mathematics (Faulinda & Aghni Rizqi Ni'mal, 2020). Thinking critical, creativity, communication, and collaboration are several skills required to face challenges in century twenty-one (Faulinda & Aghni Rizqi Ni'mal, 2020; Ivone et al., 2020; Yulianti & Wulandari, 2021). Ability this related with level thinks higher. According to findings AACU (Association of American Colleges and Universities) survey of business leaders, 93 percent of people think critically, communicate clearly, and solve complex problems. According to him, the ability is more important (Arisoy & Aybek, 2021; Gozali et al., 2021; Partono et al., 2021; Zulfa et al., 2019). Than part considerable Skills academic, more than 75% want to apply knowledge to the situation in life, with a focus on thoughts critical, solving complex problems, communication written and verbal, and learning in school and college (Fitraini et al., 2021; Mujahid & Thalib, 2019; Puteh et al., 2017).

Students' low mathematical communication skills also occur in class X SMA Yayasan Assyfa Learning Center (YALC). Most students are less able to write down the problem-solving procedure correctly. When faced with a story problem, students are not accustomed to writing down what is known and what was asked of the question before solving the problem, so students often misinterpret the meaning of the question and present a problem into a mathematical model in the form of pictures, tables, graphs, diagrams, and mathematical symbols.

The principles and standards of The NCTM (Ratnasari & Saefudin, 2018) explain that communication is a method for students to express mathematical ideas good by speaking, writing, drawing, diagramming, using an object, and presenting the form of algebra, or use symbols math. The ability to communicate mathematics could be developed through the learning of the teaching process (Hodiyanto, 2017). It is necessary is known the aspects or indicators of mathematics communication. Skills in communication mathematicians include: connecting object real, pictures, and diagrams to idea mathematics; explaining ideas, situations, and relationships mathematical oral or written with thing authentic images, graphs, and algebra; disclosing incidents daily in language or symbol mathematics; listening, discussing, and writing about mathematics; read with understanding presentation mathematics write, make a conjecture, build an argument, formulate definitions and generalizations; explain and make a mathematics question that has studied (Diandita et al., 2017; Hendriana et al., 2013; Kurniawan et al., 2021; (Ariawan & Nufus, 2017; Maulyda et al., 2021; Veralita et al., 2018).

Every student must have experienced difficulties understanding and even solving challenges in mathematics. The difficulty in expressing students' answers to the problems given by a teacher is due to their shared knowledge and the inability of children to communicate. So the development of the rainbow mathematics card is considered to be able to direct children in practicing mathematical communication skills. Robiana & Handoko (2020) revealed that the correct media is needed in learning to train students' mathematical communication. The Rainbow math card applied in TGT learning provides a solution for the diversity of students' mathematical communication skills, both high
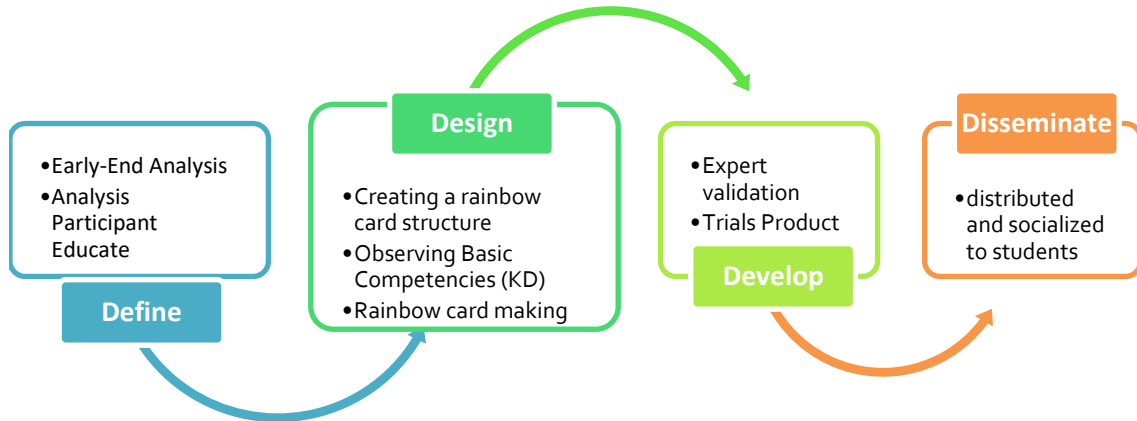
Figure 1. 4D Development Stages

and low (Fitri & Dewi, 2020).

Regardless of the heterogeneity ability of mathematics students, based on observation and interviews at SMA Foundation Assyfa Learning Center (YALC), Pasuruan obtained that inability of students to complete problem mathematics and emergence assumptions from students who think mathematics as eye difficult and tedious lesson as a consequence from unpreparedness they for the following activity learning specifically.

Students could communicate problems well in the form of pictures in mathematical models, from writing to images, or from the view into writing. The student could determine a plan to solve the problem (Sari & Pujiastuti, 2020). Remember the importance of mathematics communication ability in self-students. Because of that need, there is one learning model. one considered approach appropriate for resolving problems is a learning model cooperative *Teams Games Tournament (TGT)* with technique. Game technique estafet rainbow in is shaped game *Me Ji Ku Hi Bi Ni U* card that includes load questions that contain in mathematics communication ability and using TGT models that allow every student to do activity learning by heterogeneous, with achievement results study student through mathematics ability communication students.

METHOD

Method study used is method development, namely by Thiagarajan, Semmel, and Semmel, the 4-D model (*define, design, develop and disseminate)* used for producing the Rainbow Mathematics Card (RMC) media and testing effectiveness in increasing mathematics ability communication students with step describe in the Figure 1. The study began through observation using the 4D observation stage. Then the process carried out consists of:

Define

Activities in this phase are carried out to identify and determine development needs. This definition generally includes analysis of development needs, product development needs according to user needs, and research and development (R&D models) suitable for product development. Analysis can be done by studying the literature or preliminary research. The definition process for this phase includes initial and final observations (in this phase, analysis to observe and identify how students and teachers face math learning problems based on relevant classroom situations) and student observations (obtained from problems involving students who are less enthusiastic in

learning mathematics). Statement of learning devices and formulation of learning objectives).

Designs

During the design phase, the researcher creates the first product (prototype) or product design. Related to the development of teaching materials, this is the stage of producing teaching materials by the framework of curriculum results and analysis of teaching materials (the process of designing and designing rainbow diagrams using exponential teaching materials based on the 2013 Curriculum TGT Model). The next stage and validation of the product design. Instructors carry out product design validation in the same field. Based on the verification, the product design may need further improvement according to the verifier's suggestion.

Develop

This activity is carried out through process development which includes expert validation and testing, which experts in their fields evaluate. The suggestions given will help improve the learning materials and designs made. Development testing is a product design testing activity on a real target topic. During this trial, material experts and media experts carried out a validity card validation test to get input, suggestions, opinions, and evaluations of the cards developed. So a valid or valuable card can be obtained. Test results are used to improve our products. After the product is repaired, it will be tested for effective results.

Data using qualitative descriptive techniques after using rainbow cards for mathematics learning tools through test sheets. Sheets were given to 35 students of class X of the Assyfa Learning Center Foundation who had high, low, and

medium-level mathematical abilities, which had previously been grouped based on their ability level and were quantified to get results in the form of numbers to be measured in making rainbow cards as teaching materials. The Rainbow Card, revised based on the results of further validation, will be tested on 35 students with different mathematical abilities in class VII of the Assyfa Learning Center Foundation. All students were given a questionnaire containing questions to be filled out by students. This was done to make it easier for researchers to determine their mathematical abilities. After students fill out the questionnaire, the teacher analyzes and sorts them by grouping them according to the same mathematical ability type.

Expert Validation

Expert validation was carried out by two validators (mathematics teachers) who investigated by filling out the material verification sheet using a five-choice Likert scale (5 = strongly agree, 4 = agree, 3 = quite agree, 2 = disagree, 1 = strongly disagree).

Increasing Mathematics Communication Ability

The increasing mathematical communication skills were measured from the pre and post-test results, which consisted of 7 questions with three indicators using a paired t-test.

RESULTS AND DISCUSSION

Results

Define

Study this performed on participants at class X with exponential material. The course-made subject study is class XA,

which comprises 35 participants. The steps used are as follows.

Early-End Analysis. At this stage, it is analyzed to observe and identify how students and teachers face mathematics learning problems based on related conditions in class. When obtaining information, the device learning is still not yet adequate. A researcher found that few textbooks were available and lacked content to develop students' mathematical abilities. Based on the above problems, the research developing the Mathematics Rainbow Card media will be implemented into the TGT model.

Analysis Participant Educate. Analysis participant educates obtained problem about participant less educated enthusiastic in learning math. From the observation process received reason participant educate not interested enough because they only used learning directly, which made the participant educate bored, as well as a lot his complex formulas remember participant educate. Participants want learning that makes Becomes more active, fun, and easy to remember.

Design

This stage, the card has been designed and implemented in TGT games. The compilation design card includes customized material containing questions and answers.
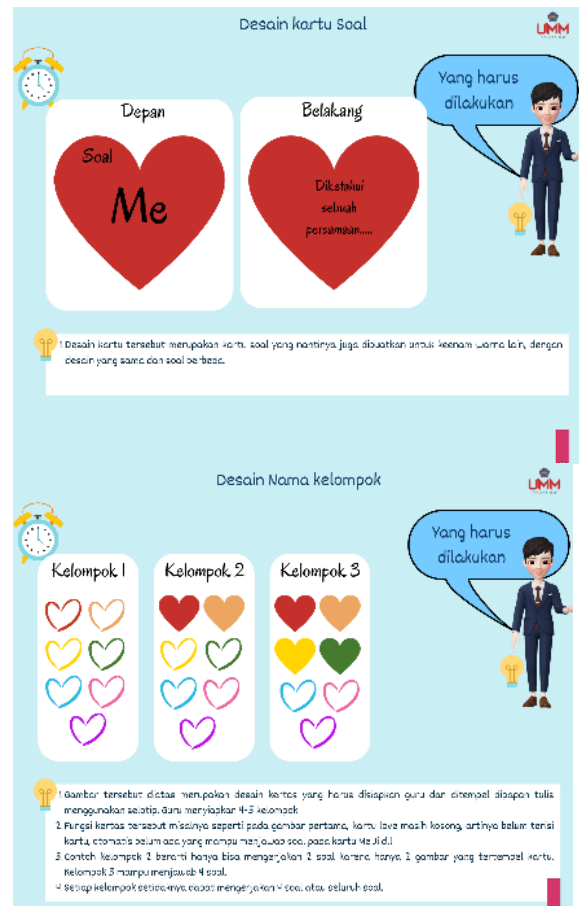

Figure 2. *Display Design Card Questions, Cards Answers, and Cards Group*

Design card questions, cards answers, and cards for each group are provided in-game in TGT stages so that users will have convenience in-game and tournament stages in developing the ability to communicate with mathematical students.

Develop

Development RMC made by experts uses questionnaires with scale *Likert.* The questionnaire consists of five choices answers, namely "Strongly Agree", "Agree", " Enough Agree", "No Agree", and "Strongly Disagree Agreed". Instrument expert assessment Theory consists of 20 items that include several aspect evaluations: aspect didactic, aspect construction, aspect technical, and quality. Instrument assessment by media experts consists of 20 items, including aspect display, size cards, and design color.
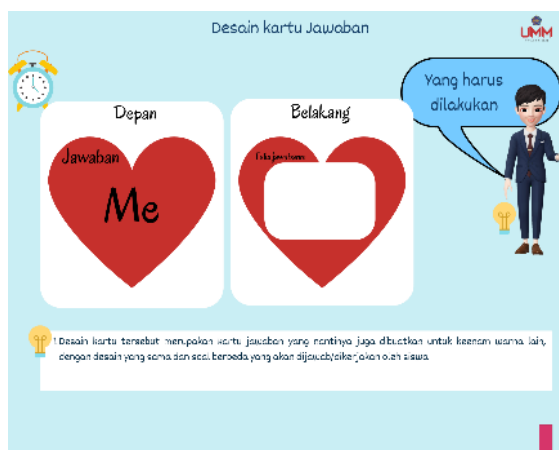
Validation Product. In this step, the validation test validity card to expert materials and media experts who aim to get input, suggestions, opinions, and evaluation of the developed card. So that obtained valid card or worthy tested. Based on the results analysis of the data used, the data received an assessment from the experts can be shown in Table 1.

Table 1. Expert Rating

Expert Rating	Score	Criteria
Material Expert	84	Very Worthy
Media Expert	83	Worthy

On the aspect of enhancement ability communication, mathematical students, based on a different test in pairs mathematics ability communication obtained significance less than 0.05 then could be said that mathematics ability communication participant educate after taught the TGT model that uses card more good compared to before. That shows there is a close relationship among RMC cards.

Disseminate

The Rainbow Mathematics Relay card developed at the final stage was then distributed and socialized to class X students through TGT learning exponent material to improve students' mathematics communication ability.

Analysis Increasing Mathematics Communication Ability

Based on the paired difference test of mathematical communication skills, the significance of the t-test was $0.000 < 0.05$, so it can be said that students' mathematical communication skills through the development of rainbow mathematics cards in the TGT learning model can improve mathematics communication ability.
Discussion

Learning Model Cooperative Team Game Tournaments (TGT)

TGT is a method of learning cooperative where game academic or tournament replace test individual (Slavin, 2005). Because of their component tournament, students no will be bored. This is an example of cooperative learning (Slavin, 2005). David Devries and Keith Edward created the Teams Games Tournament (TGT) as the first Johns Hopkins study method. TGT is almost identical to STAD in all Things except one: quiz and system evaluation enhancement individual. TGT uses tournament game academic. Slavin proposes (Gunarta 2019) that TGT is used weekly, while STAD is used only during midterm and end exams. The TGT cooperative activities allow students to be more relaxed when there is not enough responsibility, cooperation, healthy competition, and involvement in the study (Saadjad, 2021; Seran et al., 2019).

TGT learning model involves all students without looking at status, involves students as peer tutors, and includes element games and reinforcement (Falakhudin et al., 2019). When students participate in the tournament, peer tutors seem straightforward, especially when every member group asks questions and answers, then asks and learns from one another. On the other hand, TGT includes component strengthening for motivating students. TGT activities allow students to study more comfortably while not having enough responsibility, cooperation, healthy competition, and involvement in the study (Rachma Unengan et al., 2020). TGT places students in group learning that consists of 5-6 students with the ability to type different genders and ethnicities.

Game Rainbow Mathematics Card (RMC)

According to the National Research Council (Cowan, 2006), students must "do" math to develop the ability to think and solve problems. According to Matlin (Sugiman, 2009), the mathematics concept could be helpful and long stored in students' memory. The learning process must stick to the principles of meaningful learning, encouraging for applying what they have learned, and as a form of reference self, students associate Theory lessons with experience self. So that knowledge can long be stored in the memory of a student, then learning should be meaningful and fun learning for students. With fun learning, teachers do not make students afraid of being wrong in answering questions, being laughed at by friends if false, and fearing being punished. Besides, fun learning makes students bravely put forward opinions with mathematics games.

Game math has varied types and applications; mathematics teachers can choose the game based on class (Ke & M. Clark, 2020; Zaeni et al., 2017). A math teacher must smartly select the game that will be used. Because the game must have a destination besides making students happy and laugh, its implementation must be planned (Rebollo et al., 2021). Implementing game mathematics will not be vain or a waste time if destination instructional teaching is fulfilled. As a result, the game mathematics could become an effective tool.

A mathematics game that can use in learning is the theory of exponential. Exponent is the process of multiplying the same number many times. Equations and inequalities are usually used for state exponent. Master first formerly explain materials and methods count exponent for game mathematics exponential this, then the teacher gives question mathematics with load ability communication packed math in form game math. Game technique estafet used in mathematics game exponential.

Wiarto defines estafet as an "exercise performed" with a pass stick from one location to another. This exercise is repeated until all members finish it (give time for competition). The group must conduct an estafet implementation. In the estafet game, member groups must work the same. Every member of the group must understand the rule game. The game will be hampered if one member group no understand existing rules. Also, not maybe when implementing only one group playing a game, but other groups follow play because the game requires a competitive process.

Game technique estafet rainbow developed as an answer on the problem in learning math, like assumption tedious and difficult student understood about learning math. Because of that, needed innovations in education mathematics for increased motivation and achievement students have implications for attitudes toward practical students. One that can be conducted is by creating learning models of fun mathematics through games.

Learning with use technique Rainbow Mathematics Card (RMC) in the form of the game in the form of the card given name *Me Ji Ku Hi Bi Ni U* via approach scientific. Steps game of Card rainbow mathematics card (RMC) developed can be shown in Table 2.

Table 2. Steps Game Rainbow Mathematics Card (RMC)

No	Description
1	Shaping group small consisting of 4-5 students
2	A student in the group stands up or sits down and lines up backward/sideways.
3	Every group collects and exchanges information with the member group, participates in question dialogue answers between teachers and students, or looks for information through sources to learn related material that has been delivered.
4	Every member group answers question-related material discussed on the Me Ji Ku Hi Bi Ni U card given by the teacher, and students respond by taking turns with the conditioned student on duty to answer the question. Me card must finish it more first, and soon.
5	When students who get their turn first on duty answer question no able, they will be replaced by members of other groups in the line behind it. And so next until there are capable students to answer the question that. After the question Me card was missed, the team could continue on the card question next.
6	Every student is given the same opportunity to answer matters. Students wrote the work results on the card that then pasted them on the Rainbow Paper, which the teacher pasted.
7.	The whole member group will know the number of cards from each group that can be answered.
8	The teacher gives a score/rating to the card already worked.
9	The exciting results conclusion is that student participation achieves learning.

Mathematics Ability Communication

One mathematics ability that becomes a destination for learning mathematics is the ability to communicate. Mathematics Ability communication is students' ability to share mathematical ideas well through oral and writing. *According to the National Council of Teachers of Mathematics* (NCTM, 2000), ideas will perfect become object reflection through communication. During the discussion, the student will study to communicate their identity to other students using mathematical language with structured, good written verbally, as well as develop understanding you have in accordance accepted interpretation when hearing opinion student another. Mathematics communication ability is essential in learning mathematics. Because through communication, participant education could organize and consolidate think mathematics, and participant education could explore mathematical ideas (Dalimunthe et al., 2022) Ability communicate mathematical needs developed so participants could complete problems faced in learning mathematics as well as could convey the idea by written nor oral (Wahyuni, 2022).

Several standard communication mathematical, according to (NCTM, 2000), include: (1) classifying and unifying thinking mathematical students through communication; (2) convey thinking students about learning mathematics with clear and logical to a friend, peers, teachers, and people around; (3) analyze and examine mathematical ideas and strategies; (4) using language mathematical when express mathematical ideas by appropriate (Zaditania & Ruli, 2022)

Aspect communication mathematical, according to (Mahadewi et al., 2020, are: (1) Representation is the process of translating a problem or idea, a diagram for a physical model, into symbols or words; (2) Listening carefully to asking friends in a group could help students construct complete math knowledge and effectively set up more complex answer strategies; (3) Reading is an activity known actively to look for the answer that has been compiled; (4) Discussion is meant to express and reflects the students' thoughts; and (5) Write is something activity carried out by aware of expressing and reflecting

Indicator mathematics ability communication is something reference competence communication mathematical could achieve or not. Indicator mathematics ability communication in the learning process used in the paper can be shown in Table 3.

Table 3. Indicators of Ability Mathematical in Learning

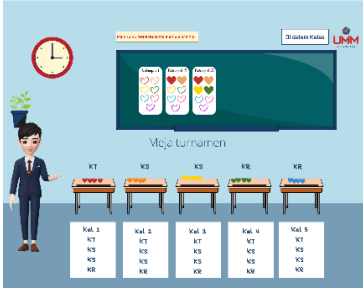| Component	Information
written text, Describe mathematical ideas, situations, and relationships in writing.	Students can write problems known and asked with appropriate
Drawing Explaining in visual form of mathematical ideas (pictures, table, or chart)	Students can present in the form of precise and clear images of ideas, situations, or solutions to mathematics problem
Mathematical Expression, Describe an idea, problem, situation, picture, or real object using mathematical symbols, models, or expressions.	Students can use mathematical models wholly and correctly to represent ideas and problem situations
	Students can represent ideas accurately using mathematical symbols

(Hikmawati et al., 2019)

Application of TGT model with RMC on mathematics ability communication

The application of the learning model TGT with RMC is described in Table 4.

Table 4. Application of the TGT Model with game Rainbow Mathematics Relay (RMC)

No	Stages		Teacher Activities	Student Activities
1	*Class Presen-tation*	a.	Apperception Inactivity, this teacher can motivate students to link Theory exponent with life every day, so could give information that theory is essential for studying.	Listen to the teacher's explana-tion and take notes theory
		b.	Application/giving Theory The teacher explains the material to be studied by students in front of the class directly through a lecture.	
2	Study in group	a.	Teacher shapes group - Inactivity this, at the beginning teacher learning already have What is the named member customized group with the group. - Formation group conducted before learning use test ability nu-meric. - Test for group students based on high, medium, or low ability. - Every group has three heterogeneous abilities. Amount members group is about 5-6 students.	Students join with shape groups by the names that the teacher has formed.
		b.	Teacher gives bait back and example question	
		c.	Direct for students who have intelligence numeric tall for driving group	
3	Games	a.	The teacher explains regulation in game estafet rainbow mathematics - Inactivity this is the teacher preparing tools and materials like paste Manila paper that says name group and Name card (colorful as characteristic typical from name game is rainbow) - Teacher makes tables 1, 2, 3, 4, and 5 tournaments - On every table tournament, cards are given the name Me Ji Ku Hi Bi Ni U. There is a question in his load indicators communication mathematical. - Students are sitting in a row backward. The student sitting in the front was chosen based on the deal member group and oppor-tunity for up.	Students listen to a good teacher's ex-planation
		b.	The teacher gives information-related methods to get scores in every tournament later. Scores were obtained from a lot of questions that can be resolved. Able students who complete questions will get a score on the table created by the teacher.	
4	Tour-na-ment	a.	Every member group answers questions related to material that has been discussed on the Me Ji Ku Hi Bi Ni U card given by the teacher, and students respond by taking turns with the conditioned student on duty to answer the question Me card must finish it first and soon.	Students follow with good every regulation in a tournament that has arranged by the teacher

No	Stages	Teacher Activities	Student Activities
		b. When students who get their turn on duty answer question no, they will be replaced by members of other groups in the line behind it. And so next until there is capable students answer. But what is necessary to notice is a student is second to replace the student first, and no continuing processing inquiry from the student first. However, the student has 2nd-star quality alone. If a student is unable, the student, when entitled to working on (also working on from the beginning) to the student first just now get turn back, can continue results quality alone until a student in the group can answer the question a card. After the question card is missed, the group could continue on the next card question.	
		c. Every student is allowed to answer and finish the question, so the student who posted the Me paper on the board writes on the form the teacher provided.	
		d. The whole member group will know amount cards from each group that can be answered	
5	Evaluation	a. At every tournament, the teacher evaluates professional student results and gives a conclusion to the results group in the game first, second, and so on.	
6	Team Recognition	Group score obtained with method sum up every group member then finds the average. Based on the group mean score will accept the description difference in his achievements from the group telling the score. The teacher can give appreciation to every group based on criteria.	Listening with an excellent related group who will announce the teacher for getting appreciation

Based on the analysis of the mathematical communication achievement indicators, it is found that for all aspects, namely writing, mathematical equations or expressions, and drawing, the Rainbow Mathematics Card in TGT Learning Model is used. Rainbow Mathematics Card in TGT Learning Model improves mathematical communication skills obtained from the standard of effectiveness caused by several factors. The first factor is the formulation of the Rainbow Mathematics Card in the TGT Learning Model, which is by the learning steps so that it does not cause an imbalance between the learning process and the media used. Second, the presentation of mathematical representation problems through cards makes students interested in finding the mathematical concepts being studied because mathematical communication makes students more thorough in understanding a concept and can relate it to other ideas in general. So seeing the image in depth makes learning mathematics more meaningful in students' memories. It looks like knowledge is not sourced from the teacher, but it is the student who actively builds the knowledge they alone together member the group by principles theory study constructivism. The teacher plays as a facilitator to ensure good learning conditions. Following an overview of models and designs, Rainbow Mathematics Card in TGT learning increases mathematics ability communication.

CONCLUSION

Game technique estafet rainbow developed as an answer on the problem in learning math, like assumption tedious and difficult student understood about mathematics learning. Because needed innovations in education mathematics for increased motivation and achievement, students have implications for attitudes toward practical students. On the aspect of enhancement ability communication, mathematical students that mathematics ability communication participant educated after being taught the TGT model that uses cards better than before. That shows there is a close relationship among RMC cards.

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