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THE URGENCE OF INTEGRATED LEARNING OF MATHEMATICS, SCIENCE, TECHNOLOGY, ENGINEERING AND ARTS

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ABSTRACT

This study aimed to describe the urgency of integrated learning in mathematics, science, technology, engineering and arts. The method used was a survey research method. The research subjects was 102 high school mathematics teachers in South Sulawesi and West Sulawesi who were randomly selected. Data was collected through questionnaires. Data collected was then analyzed by descriptive analysis. The results showed that 85% of teachers stated that all mathematical concepts taught to students could be applied to other fields of science, 11% stated that only some mathematical concepts were applirative, and 4% stated that mathematical concepts could not be applied in various fields. As many as 62% of teachers always take the initiative to integrated mathematics taught into other fields of science, 15% of teachers integrated mathematics in other appropriate fields, 11% of teachers claim to integrate mathematics was only in economics and trade, 4% integrated mathematical concepts taught to other fields if they were exemplified in textbooks, and 8% of teachers did not integrate mathematics into other fields. As many as 38% of teachers stated that students understood integration of mathematics into other fields, 27% stated that students understood integration of mathematics only in economics and engineering, 8% stated that students understood integration mathematics by examples, and 27% stated their students did not understand mathematical integration concept in other fields. In the aspect of the need to develop an integrated learning model of mathematics, science, technology, engineering, and art, all respondents stated that urgency of this learning model.

Keywords: The urgency, of Integrated learning in mathematics, science, technology, engineering and art.

1. Introduction

The development of 21st century technology is growing rapidly. Mathematics plays an important role in the advancement of science and technology, especially in the era of the industrial revolution 5.0. Mathematics has a strength that must be applied in several aspects according to 21st century skills . Mathematics is a universal science that underlies the development of modern technology. The important role of mathematics is recognized by Cockroft (Shadiq, 2014: 3), namely " *It would be very difficult-perhaps impossible-to live a normal life in very many parts of the world in the twentieth century without making use of mathematics of some kind* " . One will find it difficult or impossible for one to live in this part of the earth in the 21st century without the slightest use of mathematics. The education sector must be managed properly so that students feel the importance of mastering mathematics in advancing science and technology.

One of the basic things that need to be mastered by students in learning mathematics is knowledge and mathematical connection skills. Students are expected to have knowledge and skills to integrate mathematics in various fields of science and life as a form of mastery of students' mathematical connections. The integration of mathematics can be done in the fields of science, technology, engineering, and art.

Sulistyaningsih (2012) revealed that currently the connection of mathematics as integration in other learning is lo . Each field of science is taught separately and individually. Studies in the field of science in the curriculum also do not appear to be related to the fields of mathematics, science, technology, engineering or the arts in a comprehensive manner. Teachers also teach mathematics to the extent of deepening the understanding of concepts and problem solving procedures. Even if there is integration between fields of science, it is not comprehensive in all

fields of science. For example, mathematics is only introduced in learning as a basic skill used in solving physics and biology problems, especially in learning mathematics at the high school level. Even students are rarely facilitated to get to know technology products in the study of mathematics, science, engineering and art. Keong et al., (2005) stated that technology is essential in teaching and learning mathematics .

One of the learning innovations in several countries in the world is integrative learning in the fields of science, technology, engineering, art, and mathematics or known as STEAM Learning (Science, Technology, Engineering, Arts, and Mathematics) (Nam-Hwa Kang; 2019) . STEAM learning is gaining popularity in schools across the United States and in parts of Europe, Asia, and Australia (Herro, Quigley & Cian; 2019). STEAM-based curricula and STEAM-themed schools are popping up all over the world (Quigley & Herro, 2016).

Unlike the world's countries, Indonesia especially South Sulawesi, STEAM learning has not been implemented massively in learning in schools . STEAM learning require policy in the implementation of the educational curriculum. The curriculum needs to be developed by adding STEAM as a learning program. For this reason, teachers with expertise in science, technology, engineering, art, and mathematics are in a teaching *team* (*team teaching*) to design STEAM learning. Buinicontro (2017) defines STEAM as the integration of the arts disciplines into the curriculum and learning in the areas of science, technology, engineering and mathematics previously known as (STEM). STEAM is a meta-discipline that integrates science, technology, engineering, art and mathematics into an integrated approach that can be implemented in learning mathematics in schools.

STEAM a learning approach is a means for students to create science and technology-based ideas through thinking and exploring activities in solving problems based on five integrated disciplines (Quigley & Herro, 2016). If problem solving is done based on the integration of mathematics, science, technology, engineering and art, it will produce a very appropriate solution, not only solving mathematical problems, but based on concepts related to other disciplines so that problem solving will be very interesting, effective and effective. efficient.

To be able to develop STEAM learning, it is necessary to explore information from secondary school teachers, especially in South Sulawesi and West Sulawesi about the importance of integrating mathematics, science, technology, engineering , and the arts in one learning activity at school. This information assessment was carried out in order to obtain a profile of the views and experiences of teachers on the urgency of integrated learning in mathematics, science, technology, engineering and the arts . The existence of this paper in general can provide benefits as input for education providers to improve the quality of education in Indonesia to prepare for the 4.0 revolution generation and in particular become the basis for developing STEAM integration instructional designs in school mathematics learning.

2. Research Methods

This research is categorized as a survey research that collects teacher responses about the importance of integrated learning in science, technology, engineering, art, and mathematics. Respondents in this study were junior high school/high school mathematics teachers in South Sulawesi and West Sulawesi with 102 respondents. The data collection technique used in this study was the distribution of a questionnaire in the form of an online description which was distributed randomly.

Techniques for presenting data in descriptive statistics include tables, graphs, mean, percentage calculations. The data analysis technique in this study uses data analysis by describing or describing the data that has been collected as it is without intending to make conclusions that apply to the public or generalizations..

3. Results and Discussion

The data of this research was obtained through the distribution of questionnaires via google form to the junior high school mathematics teachers in Makassar. The questionnaire consists of 4 questions, namely: (1) Do you think that the mathematics that students learn can be applied in various fields (Science, Technology, Engineering, and Arts)? please give reasons, (2) If you teach mathematics, do you try to integrate mathematics with other fields (Science, Technology, Engineering, and Arts)?

Please give reasons, (3) In learning mathematics in class, do students understand the integration/application of mathematics with other fields (Science, Technology, Engineering, and Arts)? Please give reasons, (4) Do you think it is necessary to design mathematics learning in an integrative model (Mathematics, Science, Technology, Engineering, and Arts). Expected to be equipped with reasons. Each answer requires an explanation of whether it is necessary to integrate mathematics, science, technology, engineering and the arts in learning, especially learning mathematics.

1) Teacher Responses About Mathematics Can Be Applied In Various Fields.

The urgency of integrated learning of science, technology, engineering, art into mathematics was revealed early through a survey of teacher responses about the need for mathematics to be applied in various fields. The survey results are shown in Figure 1.

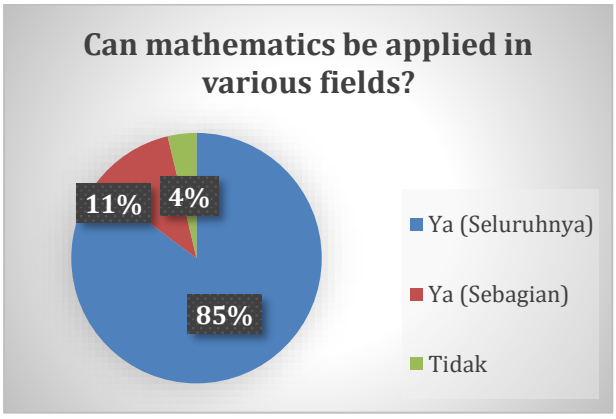

Figure 1.

The diagram in Figure 1 shows that 85% of mathematics teachers in South Sulawesi and West Sulawesi think that all mathematics materials taught can be applied in various fields science, technology, engineering, and art. These teachers claim that mathematics was the basis of all science. When mathematics is taught in schools, students will be able to develop the computational, analytical, logical, and systematic thinking skills needed to develop other fields of science. There are 11% of teachers think that only some of the mathematics content taught in schools can be applied in other fields of science. Some of the math content that the teachers meant was math material related to economics and engineering. There are 4% of mathematics teachers who think that school mathematics cannot be applied in various other fields. According to these teachers, mathematics taught in schools is solely to train students to count and solve math problems. In addition to developing computing, all school mathematics material is abstract and not practical.

2) Teacher Initiatives to Integrate Mathematics into the fields of Science, Technology, Engineering, and the Arts.

A survey on the initiative of mathematics teachers to integrate their teaching materials into the fields of science, technology, engineering, and art is needed to support the development of integrated learning designs for mathematics, science, technology, engineering, and the arts. The results of this survey are presented in the diagram in Figure 2.

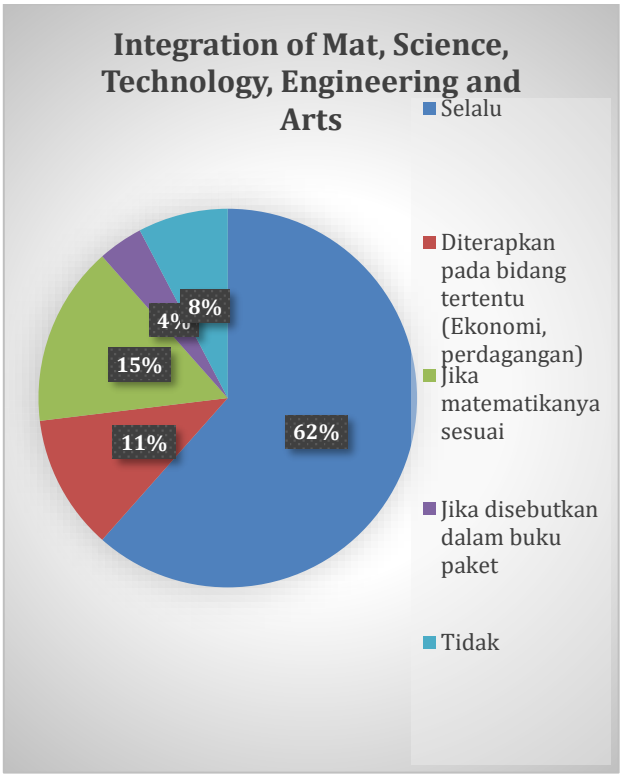

Figure 2

The survey results shown in Figure 2 show that 62% of mathematics teachers always try to integrate the mathematics taught into the fields of science, technology, engineering, and the arts. This group of teachers integrates their mathematics learning at the preliminary stage in learning activities in the classroom. The teacher tries to arouse students' interest in learning mathematics by presenting information on the importance of teaching materials that students will learn in the field of human life. In addition, the teacher also always conveys that the mathematics learned is needed to explore other fields of science, such as physics, economics, engineering, and others.

The diagram in Figure 2 above also shows that there are 15% of mathematics teachers who integrate their mathematics teaching materials into the field of science if the teaching materials are in accordance with certain fields of science. If the teacher's mathematics teaching material is seen as abstract and has no connection with other fields of science, the teacher fully teaches mathematics conceptually and procedurally in problem solving. However, if the mathematics being taught can realistically be applied to life and other fields of science, the teacher integrates the mathematics he teaches by providing information and examples of practical questions. Mathematics materials that are integrated by this group of teachers include geometry and social arithmetic. Data that is in line with the results of this survey is that 11% of teachers integrate their teaching mathematics into the fields of economics and trade. This is done because the teacher considers students to be the easiest to understand mathematics when it comes to economics and finance. In addition to the results of this survey, there are 4% of teachers who integrate their teaching mathematics if it is mentioned in the textbook that is used by teachers and students. This group of teachers has difficulty developing the integration of teaching materials if there are no guidelines and examples in the textbook for them to follow.

As many as 8% of school mathematics teachers do not take the initiative to integrate the mathematics taught into various fields of science including demonstrating its application in everyday life. This group of teachers teaches the subject matter of mathematics into three main parts, namely conveying definitions, conveying mathematical principles, then providing examples and practice questions. There are teachers in this group who understand that mathematics is not an applied science that must be integrated into other fields. There are also teachers who do not know at all how to integrate mathematics into other fields of science, including activities of daily life.

3) Teacher's Response on Students' Understanding of Applying Mathematics to Other Fields of Science.

Teachers' observations about students understanding or not the application of mathematics in other fields of science are based on the learning activities they carry out. The teacher's observations were revealed in a survey of the urgency of learning integration of mathematics, science, technology, engineering, and the arts. Data from the survey on students' understanding of applying mathematics in other fields of science is presented in Figure 3.

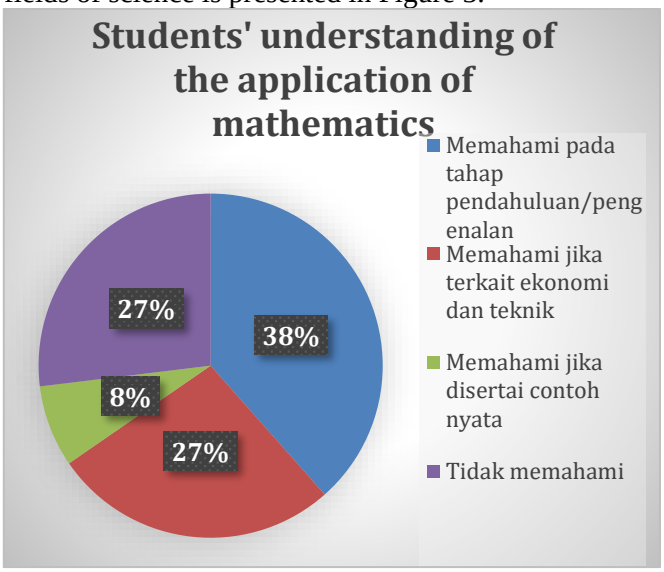

Figure 3

Students' understanding of the application of mathematics into other fields of science is low. There are a maximum of 38% of teachers who state that students understand well the application of mathematics in other fields of science and even then it is limited to the delivery of teachers in the preliminary phase who introduces the importance of mathematical concepts learned in other fields. Students' understanding has an impact on the growth of students' motivation to actively study mathematics teaching materials presented by the teacher. Other students who gain an understanding of the application of mathematics in other fields of science if the mathematical material being studied is related to economics and engineering based on the teacher's delivery. There are 27% of teachers who say so. According to this group of teachers, students find it easier to understand the application of contextualized mathematics in the field of financial economics which is related to the mathematical concept of a two-variable linear equation system and social arithmetic. In learning geometric concepts, students are easy to apply them to the engineering field. There are 8% of teachers who state that students understand the application of mathematics in other fields if it is taught by the teacher through related examples explained by the teacher. According to the teacher in this group, students can solve math application problems if the teacher has exemplified the completion procedure, even though it is categorized as a

question that requires higher order thinking skills (HOTS).

As many as 27% of teachers stated that the students who became their students in learning mathematics did not understand the application of mathematics in other fields. Such students are those who cannot explain how to apply the mathematical concepts learned. Besides being caused by not understanding the concepts being studied, it is also due to the weak ability of students' mathematical connections. Another condition that causes students not to understand the application of mathematics is that teachers who teach mathematics basically do not introduce the application of mathematics in the teaching and learning process that is held.

4) Teacher's Response about the Need for Development of Integrated Learning Models of Science, Technology, Engineering, Arts, and Mathematics.

Teachers who organize mathematics learning have responded to the importance of integrated learning between mathematics and other fields of science, however, is it necessary to develop a learning model that can guide teachers to develop integrated learning scenarios in Science, Technology, Engineering, Arts, and Mathematics. The results of the survey on such problems are illustrated in the diagram in Figure 4.

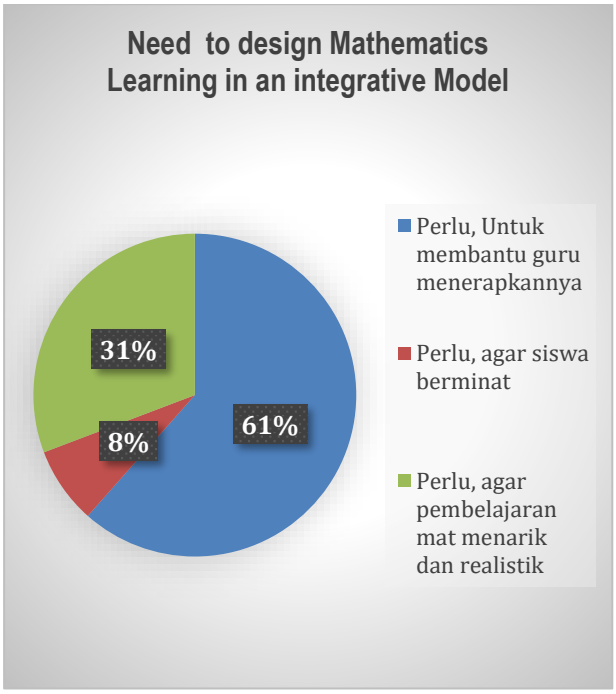

Figure 4

The diagram above shows that all mathematics teacher respondents stated the need for an integrated learning model for Mathematics, Science, Technology, Engineering, and the Arts. The reasons for the need to develop this learning model are different. As many as 61% of teachers stated that there needed to be a learning model accompanied by learning implementation guidelines and supporting learning tools. Furthermore, teachers can be trained how to apply this integrated learning model by using learning development guidelines and the use of learning tools. As many as 31% of teachers stated that it was necessary to develop an integrated learning model on the grounds that learning would be interesting and realistic for students. This is in line with 8% of teachers stating that the development of this integrated learning model is needed to develop students' interest in learning mathematics. One approach that can be used is STEAM

Research related to STEAM learning has been carried out by many previous researchers. Research conducted by Pant et.al, (2020) shows that incorporating STEAM pedagogy in mathematics learning can increase student motivation and make students learn meaningfully. The STEAM approach explains that anyone who participates in its use will explore a wide variety of topics using art and science in an intelligent and modern way (Hurley, 2019). Gani et al., 2020 have conducted research on analyzing gender-based STEAM abilities on students' Archaebacteria and eubacteria material, showing that there are differences in STEAM abilities on Archaebacteria and eubacteria between female and male students.

STEAM learning is currently growing rapidly because the STEAM theme is in line with the needs of the 21st century. The popularity of STEAM is reflected in its increasing use in various countries (Walmer, 2018; Khoiriyah et al., 2018; Musnidar, 2018). The popularity of STEAM has given rise to quite large differences in definitions from various groups regarding what STEAM is, how the term/concept is used, the context in which it is used and most importantly for whom and what it is used for (Coluci-Gray et al., 2017, 2019; Conner et al. , 2017; Costantino et al 2015; H.E. Wilson, 2018). Efforts to describe the elements of STEAM have been identified theoretically and methodologically in the field of education (Bang et al., 2012; Warren

et al., 2020). The elements of STEAM, namely science, technology, engineering, art and mathematics, are equal and have no boundaries so they are in one unit in the STEAM approach. The STEAM approach is a new structure from before (Chung & Li., 2021; Archer et al., 2019; Calabrese Barton & Tan, 2017; Nasir & Vakil, 2017; Tan & Calabrese Barton, 2018). Another interesting thing about STEAM learning in Indonesia is that it is in accordance with the K13 curriculum and is also very good for use in the Independent Learning Implementation curriculum. This is in accordance with research conducted by Ashari & Mariana (2022) that STEAM learning can be an alternative learning, can increase students' active response, interest in learning activities, and innovative teachers to implement the independent learning curriculum during learning activities.

4. Conclusions

Based on the results of the survey, 85% of teachers stated that all mathematics taught to students could be applied to other fields of science, 11% of teachers stated that only some mathematical concepts were applied, and 4% stated that mathematical concepts could not be applied in various fields. As many as 62% always take the initiative to integrate mathematical concepts taught into other fields of science, 15% of teachers integrate mathematical concepts in other appropriate fields, 11% of teachers claim to integrate mathematical concepts only in economics and trade, 4% of teachers mathematics integrates mathematical concepts taught to other fields when stated and exemplified in textbooks, and 8% of teachers do not integrate their teaching mathematics into other fields when teaching mathematics. As many as 38% of teachers stated that students understood the integration of mathematics into other fields when the teacher presented information to motivate students in the preliminary stage of learning, 27% of teachers stated that students understood the integration of mathematics only in economics and engineering, 8% of teachers stated that students understood integration mathematics if explained with examples, and 27% of teachers stated their students did not understand mathematical integration. In the aspect of the need to develop an integrated learning model of mathematics, science, technology, engineering, and art, all teacher respondents stated the need for this learning model. This design is a guide for mathematics teachers to integrate STEAM in learning. One approach that can be used is STEAM.

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