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Implementation of STEAM-Based Mathematics Learning at Junior High School during the Pandemic

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ABSTRACT

The STEAM approach is one of the learning strategies that connect fields of science with the aim of training critical, creative, innovative thinking skills and student problem-solving skills. The purpose of this study is to describe the implementation of STEAM-based mathematics learning at one of the junior high schools in Surakarta. This type of research is qualitative descriptive, with the subjects being 16 students of class IX and one STEAM learning teacher. Data collection techniques used are interviews, observations, and documentation. Data analysis is done through data reduction techniques, data presentation, and conclusion drawing. The results showed that STEAM-based mathematics learning implemented a shift system where the number of student attendance was only 50% of the total number of students in the class. The learning process uses the Project Based Learning model because mathematics learning in one of the junior high schools in Surakarta is implemented into creating a STEAM project with group discussion methods. STEAM-based mathematics learning covers aspects of STEAM. Science is associated with everyday problems, such as applying pascal's law to elevators. Technology is implemented on the use of tools and materials. Engineering is associated with the ability of students in solving problems, one of which is in assembling a project. Art includes the ability of students to create a project. Mathematics is related to calculating and measuring a project. As for the problems experienced by teachers and students during the pandemic of the new normal era, is the estimated time given to complete a project.

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1. INTRODUCTION

Education is an important aspect of the progress of a nation. The essence of education is an effort to increase the knowledge of students through formal or informal levels to produce a generation of nations that are qualified, insightful and characterful (Apsari & Rizki, 2018; Harahap et al., 2021; Sirajuddin, 2017). The activeness of learners in learning and the involvement of the values that students get for their lives become an important part of the quality of education (Surya et al., 2017). One example of formal education that prioritises the activeness and involvement of learners is mathematics education. Mathematics is a subject that must be given at all levels of education to improve learners' cognitive ability in solving problems (Annizar et al., 2020; Kusumaningtyas et al., 2017; Ngaeni & Saefudin, 2017). Mathematics is also called the mother of science because almost every aspect of life and knowledge is very close to mathematics (Rismawati & Asnayani, 2019).

Mathematics learning is the process of giving learning experiences to learners to understand the meanings, relationships and symbols that can be implemented in everyday life. But in its application, there are still many learners who view learning mathematics as difficult so they often experience mistakes in solving problems (Febriana et al., 2020; Haryanti, 2018; Istikomah & Wahyuni, 2018). Difficulty understanding concepts and applying mathematical materials in everyday life is still often experienced by learners. In addition, learners' lack of knowledge regarding the implementation of mathematics in technology is also an obstacle to the mathematical learning process. The difficulties experienced by students are usually caused because teachers are not precise in designing learning (Firdaus, 2016; Wijaya, 2015). Therefore, the right learning design is needed to be able to overcome these problems, one of which is by using the STEAM approach (Science, Technology, Engineering, Art, and Mathematics) (Oktaviani et al., 2020).

STEAM is an approach to make it easier for students to connect between fields of science to practice critical and innovative thinking skills (Atmojo et al., 2021; DeJarnette, 2018; Jantakun et al., 2021). The STEAM can make it easier for students to connect one material with other materials. In addition, students can develop their potential in science, technology, engineering, art and mathematics in lessons. The STEAM approach can also develop creativity, critical thinking skills, cooperation and communication between students. STEAM's approach applied in schools provides teachers with opportunities to create innovative and challenging learning for students (Quigley & Herro, 2016; Suriyana & Novianti, 2021). In the STEAM approach, students can easily understand mathematical concepts so that they can solve the problems they experience (Oktaviani et al., 2020). The STEAM can help students overcome their misconceptions and difficulties in connecting materials and between subjects. Steam's approach has advantages, including: (1) expanding students' knowledge of science, (2) improving students' skills in critical thinking, creativity, innovation and cooperation, (3) allowing students are able to implement knowledge into technology in everyday life (Harahap et al., 2021).

(Harahap et al., 2021) Concluded that the steam learning approach in class VII has a good impact, so that students can understand mathematical concepts and solve mathematical problems well which it affects the improvement of students' mathematical communication skills. In line with this research (Harahap et al., 2021; Suriyana & Novianti, 2021). Regarding the effectiveness of the STEAM learning approach concluded that this approach runs well that it can improve the mathematical communication skills of learners. STEAM's learning approach also makes learners more active in learning inside and outside the classroom. This positive learner response, it proves that the STEAM approach has been well implemented. Previous research on STEAM learning, (Shatunova et al., 2019) concluded that STEAM's learning approach is effective in the development of competency capabilities and the ability to work in the face of the 4.0 era. Steam or STEM approaches equally have a good influence on learners, including improving the ability to think critically, creatively, and independently in solving a problem (Abdurrahman et al., 2019; Farwati et al., 2021; Khotimah et al., 2021; Supriyatun, 2019).

The research conducted by Nurhikmayati (2019) explains the implementation of STEAM-based learning in schools and how to apply the STEAM approach in learning mathematics. The study also explained examples of the application of STEAM-based mathematics learning. However, this study did

not explain the problems that occur in the implementation of STEAM-based mathematics learning. Facts in the field, there are still some problems experienced by teachers and students in the application of STEAM-based mathematics learning. With this, the problems that occur and solutions are discussed in the research made by the researcher.

The research is conducted by (Farwati et al., 2021; Khotimah et al., 2021), namely the implementation of STEAM-based mathematics learning. The implementation of STEAM-based mathematics is presented from the collection of various library data related to the implementation of STEAM learning. This study did not describe the conditions that occur in the field related to STEAM-based learning in schools, such as STEAM products produced, problems experienced by students and teachers and solutions to problems that occur in schools. In contrast, this article describes the products produced in STEAM-based mathematics learning and the various obstacles and solutions given to the problems experienced by teachers and students.

SMP Batik Surakarta is one of the high schools in Surakarta that has implemented STEAM-based learning. During this pandemic, there were significant learning changes, one of which was STEAM-based mathematics learning at Surakarta Batik Junior High School. Therefore, based on the background above, the purpose of this study is to describe the implementation of STEAM-based mathematics learning and its constraints at Surakarta Batik Junior High School during the pandemic. The importance of this research is to find out more about STEAM-based mathematics learning in a school in Surakarta so that the STEAM approach can be applied in various schools in Indonesia in the future. Hope for further research in order to examine a more innovative and effective STEAM approach to be applied.

2. METHODS

This research is qualitative descriptive research. The research was conducted at SMP Batik Surakarta in Semester 1 of the Academic Year 2021/2022 during the new normal era pandemic. The subjects of this study were class IX students and STEAM learning teachers at Surakarta Batik Junior High School. The data collection techniques used are observation, interviews, and documentation. Observations are carried out to collect data on steam implementation related to the model, method, media and materials used. Interviews are used to get information about the implementation and problems of STEAM-based mathematics learning during the pandemic. The subjects interviewed were three students and one Surakarta Batik Junior High School teacher. The teacher chosen is a mathematics teacher who teaches STEAM at Surakarta Batik Junior High School, while the selected students are students with high ability in STEAM-based mathematics learning in the hope of providing information related to the implementation and problems of STEAM-based mathematics learning.

The instruments used in this study are interview guidelines for teachers and students and observation guidelines. The interview guidelines contain a grid of teacher and student interview questions and teacher and student interview questions. The observation guidelines contain research observation sheets on teachers and students. The process of data analysis is through data reduction techniques, data presentation, and conclusions (Miles et al., 2014). Data reduction is obtained from research data that is then reduced and summarised to get the main things or a sharper picture of the observation results of STEAM implementation. The presentation of the data displays a description of the results of observations obtained from observations, interviews and documentation. In the next stage, researchers conclude from the data discussed. The data validity is determined by triangulation of sources and techniques. Source triangulation is combining data from multiple sources. While triangulation technique combines data from several techniques.

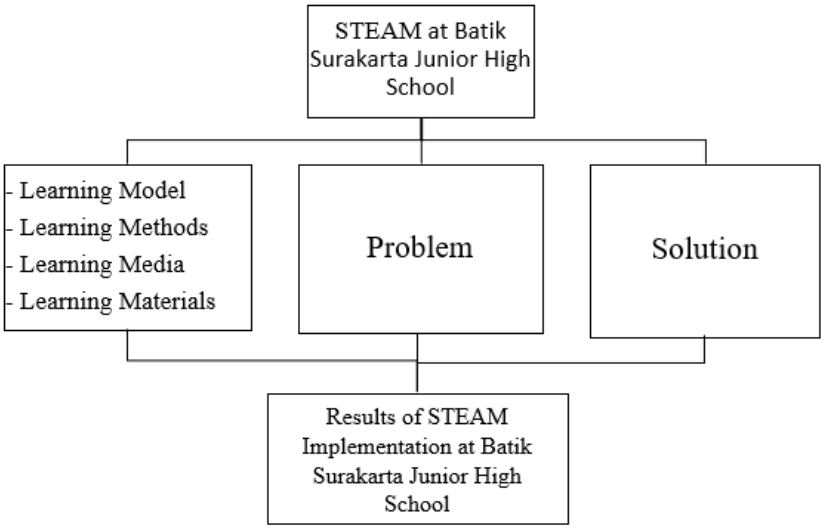

Figure 1. Research Method Framework

3. FINDINGS AND DISCUSSION

Implementation of STEAM-Based Mathematics Learning at Surakarta Batik Junior High School During the Pandemic

STEAM-based mathematics learning at Surakarta Batik Junior High School at the beginning of the pandemic was carried out online or in daring. The implementation of STEAM-based mathematics learning is carried out through e-learning media where the learning media uses Microsoft Teams. All STEAM-based mathematics learning activities are carried out using the application. Here are the results of interviews with STEAM-based math learning teachers.

> P: "How to implement STEAM-based mathematics learning during the pandemic, Miss?"
> S1: "At the beginning of the pandemic, learning using the online system used to use Microsoft Teams. There, students can access all the materials I provide and as a collection point for assignments. In addition, sometimes learning through video meetings that are held also uses the meeting menu in the application."

Using online learning media with the Microsoft Teams application can be an alternative for teachers in carrying out learning during the pandemic so that learning goals can still be achieved. In addition, the use of e-learning media such as Microsoft Teams provides its own colour for students because it is a new experience for them so students are enthusiastic about following the STEAM-based mathematics learning process there. Supported by the results of an interview with one of the students or master's degree as follows.

> P: "What do you think about using e-learning media like Microsoft Teams in STEAM-based math learning?"
> S2: "It's interesting, because it's the first time also using the Microsoft Teams application for learning this time. In addition, the application makes it easier for me to access and learn materials anytime and anywhere, so it is more flexible to learn."

Microsoft Teams is a learning medium in the form of applications used in STEAM-based mathematics learning at Surakarta Batik Junior High School during the pandemic. Figure 2 shows the appearance of the Microsoft Teams app.

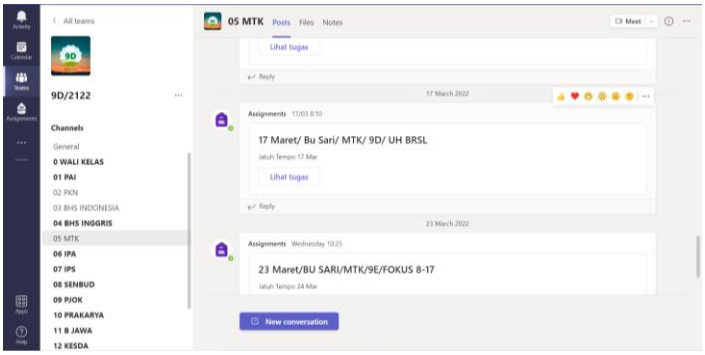

Figure 2. STEAM-Based Math Learning Teams View

STEAM-based mathematics learning carried out at SMP Batik Surakarta when online is implemented in the creation of STEAM projects only the difference is when online making this project is carried out in their respective homes and the work is individual. Learners are directed to create a product in which the product of the project covers aspects of STEAM. In the implementation of STEAM-based mathematics learning regarding the creation of the project, teachers apply the learning process based on aspects of STEAM. In the aspect of science teachers provide daily problems in the form of STEAM projects, where in the creation of the project, the teacher directs students to utilise the goods in the surrounding environment. In the aspect of technology, teachers use learning media in the form of Microsoft teams applications where the application is used in the online learning process to provide materials, collect student assignments and as a place for video meetings with students during learning. Engineering aspects include students' knowledge of using these learning media and the ability to assemble projects. Furthermore, in the aspect of art, teachers give students flexibility in creating STEAM products made so as to produce a project that has high artistic value. In the aspect of mathematics, mathematics is used in processing findings, including calculating, measuring, comparing and classifying a form in STEAM products made by learners.

In the implementation of STEAM-based mathematics learning in the new normal era, SMP Batik Surakarta imposed a new offline system by prioritising strict health protocols. Based on the results of observations at SMP Batik Surakarta, offline learning is carried out with a shift system where learning is divided into two sessions, namely morning and noon. The implementation of the shift system in STEAM-based mathematics learning caused in one learning meeting the attendance of learners in the classroom only 50% of the total number of learners in one class, where 16 learners did learning in class in the morning and 16 other learners carried it out during the day. The division of learners who participate in learning in the classroom is divided based on the ownership of even and odd absentee numbers. Interviews were conducted to teachers of STEAM-based mathematics learning.

> P: "What about implementing learning in this new normal era Miss?"
> S1: "If in this new normal era the learning is offline with the shift system. In one meeting, there were 2 sessions, namely in the morning, which entered 16 students with odd absences and 16 students with even absences entered noon. But it is not always absent odd morning and even noon but in the next meeting later behind that absent even enter the morning and odd absent enter noon.".

Implementing the shift system in the learning process in the new normal period caused the number of learners present in the classroom to only half of the total number of students in the class. As shown in Figure 3 where there are 16 students who follow the STEAM-based mathematics learning process by prioritising strict health protocols.

Figure 3. STEAM-Based Math Learning Atmosphere With Shift System

The application of STEAM-based mathematics learning at Surakarta Batik Junior High School has differences compared to the application of other subject learning. The difference lies in the learning process and the learning material provided is a mathematical material that has a relationship with aspects of STEAM. STEAM-based mathematics learning at SMP Batik Surakarta is implemented into the creation of a project that covers aspects of STEAM. In the process of STEAM-based mathematics learning teachers use the Project Based Learning (PjBL) learning model, where the PjBL learning model is very suitable to be applied in learning there because it is both project-based. The results of the interview with steam-based mathematics learning teachers also reinforce that the PjBL learning model is very suitable to be applied.

P : "What learning models are used in STEAM-based mathematics learning here Miss?"
S1 : "The learning model used is PjBL because STEAM is project-based and the PjBL model is also based on a project so that the two things are suitable and interconnected."

STEAM-based mathematics learning at Surakarta Batik Junior High School was held as many as 24 meetings in one semester. In the first semester, students are given two STEAM projects related to mathematics materials, where each project has a completion period of 12 meetings. One of the projects given is the hydraulic lift. The hydrolic lift project as shown in Figure 4, is one of the STEAM projects in the first semester.

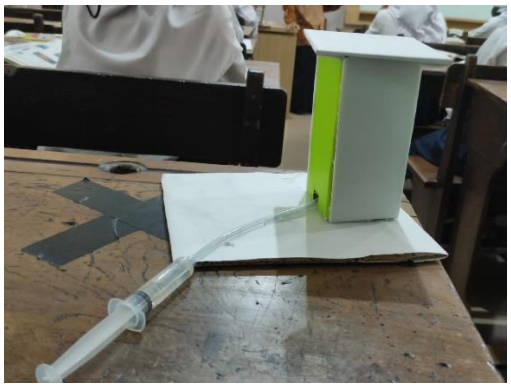

Figure 4. Hydraulic Lift Project

Hydraulic lift is a lifting device used to lift an object, where this tool includes the concept of revival and partnership and also in the tool applies pascal's law in it. The hydraulic lift project is a project created based on the concept of revival and partnership and covers aspects of STEAM. The first aspect, science shows the application of pascal's law in the hydraulic lift working system, where pascal's law explains that the pressure exerted on a liquid in a closed space will be passed on by the liquid itself in all directions equally large. Thus, in this hydraulic lift project, if given pressure on the injection below

it can lift the objects above. This can be shown in Figure 5 regarding the application of pascal concepts in the hydrolic lift work system.

Figure 5. Application of Pascal's Law on Hydrolic Lifts

The second aspect, technology, is associated with the use of tools and materials such as used cardboard, *lidi* or toothpicks, firing glue, injection toys, hoses, scissors/cutters, ruler, ballpoint pens/pencils, paper or used calendars and water. These tools and materials are used to create hydraulic lift projects as shown in Figure 6.

Figure 6. Tools And Materials Used To Make Hydraulic Lift

The third aspect, Engineering, is associated with the ability of learners to explore assembling projects. In doing a hydraulic lift project, it takes the ability of learners to make and assemble all tools and materials so that it becomes the desired project. As in Figure 7 shows that learners are exploring in the aspect of assembling hydraulic lift projects.

Figure 7. Assemble Process In Creating Hydrolic Lift Project

The fourth aspect, Arts, is associated with the selection of cardboard colours or it can also be with the manufacture of models of each part. Learners are left to create a hydraulic lift project so that the project becomes a product that has high artistic value. It can be seen in Figure 8 shows that the project worked on by students has a different shape and colour but is still conceptualised on the hydraulic elevator project.

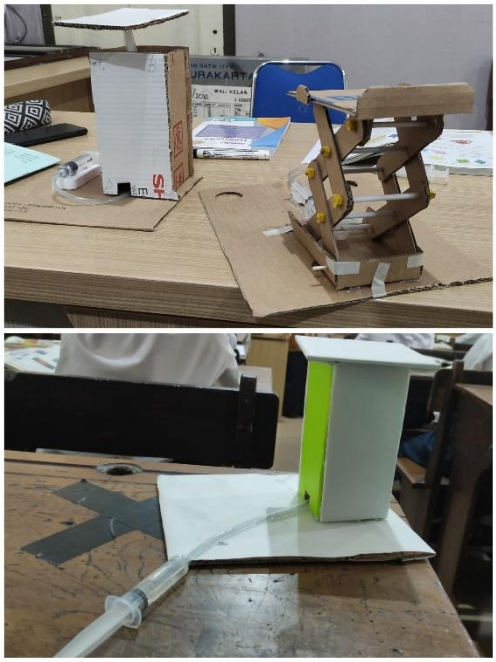

Figure 8. Diversity of Shapes and Colors of hydraulic lift project

The fifth aspect, Mathematics, is associated with measuring each element that requires the concept of revival and partnership to be well united. In this hydraulic lift project, the existing mathematical aspects can be associated with the concept of partnership and revival, where this project can be shown on the side that is green and white. To make this hydraulic lift a successful project, the green side must be congruent with the front side, which is green as well, then the white side must also be congruent with the white front side. This can be described when the teacher explains the concept of partnership applied to the hydraulic lift. Figure 9 shows the results of the documentation when the teacher explains the concept of partnership in the hydraulic elevator.

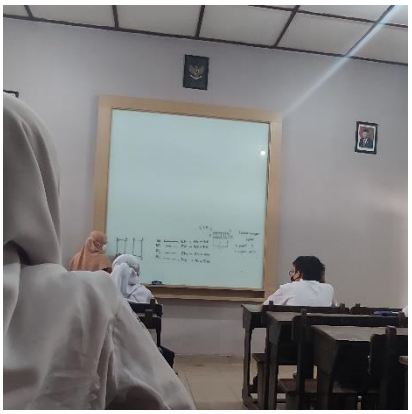

Figure 9. Application of Mathematical Aspects in Hydrolic Lifts

In this aspect of mathematics, the teacher explained the concept of partnership in the hydraulic lift project, where it can be seen on the green side is expressed with a rectangle of ABCD and EFGH that the teacher describes on the board. This partnership concept can be seen from the AB side corresponding to the EF side, the BC side corresponding to the FG side, the CD side corresponding to the GH side, and the AD side corresponding to the EH side. Congruence here are meant to be of the same shape (the size of the same corresponding angle) and the same size (the same corresponding side length).

Based on the results of learning observations, at the first meeting the teacher gave the material of revival and partnership first and then conveyed the introduction and understanding of the hydraulic lift project to be made. In providing materials, teachers use PowerPoint media and learning videos (technology) related to the material delivered. After that, the teacher gives questions to students related to the concept of revival and partnership with the question and answer method in the classroom to ensure students' understanding of the material or concept. Then the teacher introduces and provides an understanding of the hydraulic lift project to be created, where students are given an understanding of the hydraulic lift project and its relationship with aspects of STEAM. Furthermore, the teacher explains the tools and materials needed in the creation of the project, and then students are explained the instructions for the steps to create a hydraulic lift project in detail so that students can better understand it. Students begin the practice of creating hydraulic lift projects at the second meeting until the twelfth meeting, and after that the learner can present his work in front of the class. In the creation of the project, the teacher uses a group discussion method so that one project is carried out by 6 students. It is able to train students to work together in groups and make it easier for them to complete hydrolic lift projects. Supported by the results of an interview with one of the students of class IX or S2 as follows.

P: "What do you think about the application of group discussion methods in completing this hydrolic lift project?"

S2: "I think the application of group discussion methods can make it easier for me to complete the project because it is done together with group friends and can ask my friends if there are things that I do not understand."

Problems and Solutions for Implementation of STEAM-Based Mathematics Learning at SMP Batik Surakarta

In implementing STEAM-based mathematics learning during the pandemic of the new normal era at Surakarta Batik Junior High School, there are problems or obstacles related to the STEAM learning process experienced by teachers and students. Moreover, during the pandemic of the new normal era, many changes related to the learning system caused by the transition from offline to online learning resulted in many obstacles experienced by teachers and students.

The problems experienced by teachers and students during learning in this new normal era are found in the learning model used, namely PjBL. Although the PjBL learning model has been felt in accordance with STEAM learning, where both things are project-based, it takes a long time to complete with the project. This is not in accordance with the time specified by the teacher where the time given is limited so that the project collection period is late which causes the presentation time to be delayed and less optimal. The results of the interview with the following teacher or S1 support the above statement.

P : "What obstacles do you experience while applying the PjBL learning model?"

S1 : "For obstacles may be in the time yes, actually awry also because the name of the project was done with a long period of time, but the time that the school determines is limited considering one semester is only 6 months and for one semester do 2 projects. So yes, it is less than the maximum possible."

The PjBL learning model teachers apply in STEAM-based mathematics learning still has its drawbacks, which lie in the estimated time to complete a project. This prompted researchers to provide a view of the solution to the problem. The solution of the problem of learning in the new normal era is that teachers can increase the number of group members so that it is expected that the division of tasks of each learner is lighter and the project is quickly completed. In addition, by reducing the number of projects given that it is expected that students can complete the given project to the maximum.

Discussion

STEAM-based mathematics learning during the pandemic that was implemented experienced a change in the learning system where initially offline became online and then turned offline in the new normal era by prioritising strict health protocols. The implementation of STEAM-based mathematics learning when online is done through e-learning media where the learning media uses the Microsoft Teams application to make it easier for students and teachers to interact about learning online. In line with the results of the study (Hatip & Listiana, 2019; Sa'ida, 2021). This states that the use of learning media such as Microsoft Teams can help teachers and students in carrying out STEAM-based mathematics learning is still carried out properly according to learning goals, even if it is carried out online. In addition, STEAM-based mathematics learning carried out online through e-learning media and learning videos provides its own colours for students so that they are more enthusiastic and can provide students with flexibility in accessing and studying materials anytime and anywhere. This is in line with research conducted by (Agustina et al., 2022; Apsari & Rizki, 2018; Purwasih & Elshap, 2021) stating that utilising e-learning media online can help teachers and learners in accessing learning materials so that learning goals can be conveyed properly.

The learning model used in STEAM-based mathematics learning is PjBL, where the learning model is the teacher's choice because STEAM learning is project-based learning and it is very equivalent to the PjBL learning model, where the learning model can improve the cognitive abilities and problem-solving skills of learners. This is in line with the results of research conducted by (Anggito et al., 2021; Harahap et al., 2021; Hawari & Noor, 2020; Khotimah et al., 2021) which concludes that the PjBL learning model is very suitable when implemented in STEAM-based mathematics learning in addition to that with a project-based learning model can train learners' skills in critical thinking, creative, innovative, and problem-solving skills.

The PjBL learning model is a project-based learning model where it takes a long-term time to complete a given project. However, this is an obstacle for teachers and students where the period of completion is limited and projects are carried out more than one project, so there are often delays in students collecting tasks and projects that have been done. Research conducted by (Nurhikmayati, 2019) Explained that project-based learning such as STEAM requires a long learning period where it aims to make the learning and projects carried out provide maximum results.

4. CONCLUSION

The implementation of STEAM-based mathematics learning at the beginning of the pandemic was carried out online or online using e-learning media, namely by using the Microsoft Teams application. Meanwhile, when the new normal conditions of learning are carried out offline with strict health protocols, the presence of students in one class is only 50% of the total number of students in class. STEAM-based mathematics learning is carried out with a shift system; namely, Some students study in class in the morning, and some other students enter during the day. STEAM-based mathematics learning is implemented in the creation of a project that covers aspects of STEAM. Aspects of STEAM that exist in mathematics learning in SMP Batik on the hydraulic lift project include science associated with the application of pascal law in the hydraulic elevator work system, technology is related to the utilisation of tools and materials, Engineering is associated with the ability of learners in exploring assembling projects, Arts is associated with the selection of cardboard colours, or it can also be with the manufacture of models of each part. Mathematics is associated with the measurement of each element that requires the concept of revival and partnership in order to be well united. The STEAM-based mathematics learning process is carried out using the PjBL learning model with discussion and Q&A learning methods. At the first meeting of learning, teachers provide material in the form of mathematics materials for revival and partnership and then provide an introduction and understanding of the project that will be carried out by students in a group discussion at the second meeting until the twelfth meeting.

The problem experienced during the STEAM-based mathematics learning process is the lack of learning time, especially in the completion of STEAM projects where the use of PjBL learning models should be applied for a long time so that it becomes its own constraint.

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