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DEVELOPMENT OF STEAM-BASED E-HANDOUT TO IMPROVE MATHEMATICAL CONNECTION SKILLS AT UPT SMP NEGERI 41 MEDAN

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ABSTRACT

This paper discusses an e-handout of STEAM-based circle material to improve mathematical connection skills at UPT SMP Negeri 41 Medan. The research and development design (R&D) uses the Thiagarajan model. The research results imply that the STEAM-based e-handout met the criteria of valid, practical, and improved mathematical connection skills. Material experts provided an average score of 81% (very valid), linguists provided an average of 80% (fairly valid), and media experts provided an average score of 100% (very valid). The average score of the teacher's response to the practicality of the e-handout was 75% (practical) and the student's percentage was 67% (practical), which means that teachers and students have a positive response. Mathematical connection skills at UPT SMP Negeri 41 Medan met the criteria of effectiveness. It is shown in the second trial in which the learning objectives that were achieved from the three mathematical connection indicators exceeded 75% and students' learning completeness was 96%. The improvement in students' mathematical connection skills with an average N-gain score in trial I and trial II indicate an improvement score of 0.134. It can be concluded that the developed e-handout is valid, practical, and effective, as well as it can improve mathematical connection skills.

Keywords*: *e-handout, STEAM, mathematical connection skill

PENGEMBANGAN *E-HANDOUT* BERBASIS STEAM UNTUK MENINGKATKAN KEMAMPUAN KONEKSI MATEMATIKA DI UPT SMP NEGERI 41 MEDAN

ABSTRAK

Tulisan ini membahas hasil *e-handout* materi lingkaran berbasis STEAM untuk meningkatkan kemampuan koneksi matematis di UPT SMP Negeri 41 Medan. Rancangan penelitian dan pengembangan (R&D) menggunakan model Thiagarajan. Hasil penelitian menunjukkan bahwa *e-handout* berbasis STEAM memenuhi kriteria valid, praktis, dan meningkatkan kemampuan koneksi matematis. Ahli materi memberikan skor rata-rata 81% (sangat valid), ahli bahasa memberikan skor rata-rata 80% (cukup valid), dan ahli media memberikan skor rata-rata 100% (sangat valid). Skor rata-rata tanggapan guru terhadap kepraktisan *e-handout* adalah 75% (praktis) dan persentase siswa adalah 67% (praktis), artinya guru dan siswa memiliki respon yang positif. Kemampuan koneksi matematis di UPT SMP Negeri 41 Medan telah memenuhi kriteria keefektifan. Hal ini ditunjukkan pada uji coba kedua yang dilakukan, yang mana tujuan pembelajaran yang dicapai dari ketiga indikator koneksi matematis melebihi 75% dan ketuntasan belajar siswa secara klasikal sebesar 96%. Peningkatan kemampuan koneksi matematis siswa dengan skor N-gain rata-rata pada uji coba I dan uji coba II diperoleh peningkatan sebesar 0,134. Dapat disimpulkan bahwa *e-handout* yang dikembangkan valid, praktis, dan efektif serta dapat meningkatkan kemampuan koneksi matematis.

Kata Kunci: e-handout, STEAM, kemampuan koneksi matematis

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INTRODUCTION

The current learning process really needs media with technology-based assistance. Because the learning that was applied during the Covid-19 pandemic was carried out using the blended learning method . To attract students' attention in each learning process, there is an attraction to the learning devices used. Teaching materials should be made as attractive as possible starting from the content, appearance, design, access to teaching materials and so on so that students do not feel bored and can increase their understanding and more information about the material presented, as well as make it easier for students to learn. The achievement of learning and understanding

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needed during the industrial revolution 4.0 towards the era of society 5.0 becomes less meaningful. Unesco (2017) stated that in the era of the industrial revolution 4.0 education with human movement in digital and technological behavior, and for the future, namely the era of society 5.0, is a pattern of information exchange that has been formed so that Big Data is obtained from the internet.

Mintowati (2003) states that in achieving learning success, one of the tools needed is teaching materials. Things that can make it easier for students to learn and increase student enthusiasm for learning, namely using digital teaching materials that can be accessed on computers or cellphones on Android and IOS platform users , namely the type of teaching material in the form of electronic handouts (e - handouts) with a special approach that has not been teaching materials in the school. "The handout contains a summary of the important concepts of a material so that it can make it easier for the reader to master, understand and remember the concepts being studied" (Sanaky: 2011). E- handouts are a form of teaching material with an electronic version made with the help of applications/software that can be viewed via a cellphone or computer and e-handouts are far more practical than handouts in printed form (Nurjanah, 2021) .

In order for students to easily access e-handouts , the authors use the Canva application/software. Currently the world of education is about to enter the 21st century, but Trisdiono (2013) states that entering the 21st century the existence of Human Resources (HR) in Indonesia is not competitive. For this reason, schools must be able to prepare students to enter 21st century education, because the 21st century learning paradigm emphasizes students' abilities to find out from various sources, formulate problems, think analytically and work together and collaborate in solving problems (Ministry of Education and Culture Research and Development: 2013). This relates to the connection skills that students have in preparing for future abilities .

To be able to support 21st century learning, an interesting learning model or approach is needed and can improve mathematical connections, one of which is STEAM. According to Guy A. Boy and Yakman, STEAM (Science, technology, engineering, Art, Mathematics) is an integrated approach to be able to encourage creativity and seek interrelationships with one another. Moreover, the addition of art / art in STEAM. Lestari et al (2018) stated that STEM involves "4C" competencies in learning such as creativity , critical thinking, collaboration, and communication .

By using e-handouts based on the STEAM approach, students can develop and have the ability to connect the material studied to everyday life or the surrounding environment. So that the concepts contained in mathematics are assessed by students as interconnected concepts (MD Siagian, S. Suwanto & R Siregar, 2021). Turiman (2018) states that mathematical connection is the application of mathematical concepts to solve problems in everyday life that students must have as basic abilities. Based on the research results of Rosliana Siregar, et al. in the worksheet based on the TPS learning model that "the ability to make mathematical connections is currently a necessity for students, given the hierarchical and interrelated mathematical concepts". According to NCTM in Linto (2012) indicates that students' mathematical connections are: 1) aspects of connections between mathematical topics, 2) aspects of connections with other sciences, and 3) Aspects of connections with the real world of students/connections with everyday life. The results of the tests given to several students showed that the students' mathematical connection skills were very low, so students were unable to show indicators of these mathematical connection abilities.

Nurhikmayati (2019: 42) explains that learning with the STEAM approach is a means for students to create science and technology-based ideas or ideas through thinking and exploring activities in solving problems based on five integrated disciplines. in the STEAM approach there are various learning models that can be used. In this study, the learning model used is based learning (PBL). The PBL learning

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model is oriented to authentic problems from real life and is able to train and develop students' abilities to solve problems (Aris Shoimin , 2014 : 129).

Based on tests conducted by several students, students were less able to present known information. This means that students are less able to connect concepts, topics of mathematical problems in everyday life. The abilities that students lack are also influenced by the learning model/approach used and teaching materials that are less attractive to students' learning interest.

In this case the considerations made by researchers in even semesters in class VIII are developing STEAM-based e-handouts in order to produce e-handouts that are valid, practical and effective and can improve mathematical connection skills at UPT SMP Negeri 41 Medan on circle material.

REASERCH METHOD

This research uses research and development methods at level 4. According to Sugiyono (2019), research and development at level 4 is creating and testing the effectiveness of newly created products and functions to validate and develop products. This research was conducted using a quasi-experimental (quasi-experimental) with a one group pretest-posttest design. This research focuses on developing the results of STEAM-based e-handout learning products to improve mathematical connection skills.

The procedure for developing learning tools used by researchers is based on the Thiagarajan model. The stages of the thiagarajan model consist of define, design, develop and disseminate . The research was conducted at UPT SMP Negeri 41 Medan for the 2021/2022 academic year. the population used was class VIII while the sample used was two classes, namely class VIII-5 with a total of 25 students as a trial product that had been revised and 1 class again as a control class (not as a comparison class).

The research instrument consisted of practicality questionnaires, validation sheets and test questions. The data analysis technique used is validity test, practicality test and level of effectiveness. The increase in mathematical connection ability is determined based on the N-gain value from the students' post-test results.

RESULTS AND DISCUSSION

The research obtained research results using the Thiagarajan model. This research is limited to 3 stages , namely : define, design and develop .

Define

Details of the research steps at the define stage carried out an initial analysis with findings during open interviews, namely students using the 2013 curriculum with material according to KI, SK, and KD. The problem faced by the teacher when carrying out learning is that students are lacking in criticizing existing problems so that there is a lack of interest in learning mathematics. In solving problems in everyday life, students find it difficult to connect in real life because in the books students have there are not many examples that students will understand. The teaching materials used by students are textbooks from the Ministry of Education and Culture. Which in the book on circle material lacks examples of questions that can improve students' connection skills and knowledge in solving problems in everyday life, especially in aspects of connection to other sciences. For this reason, the right solution for teaching materials that students will use is to be able to improve students' mathematical connections and increase their interest in learning mathematics by developing STEAM-based e-handouts on circle material. Furthermore, in the analysis of students seen from the knowledge tests carried out, namely students do not understand questions related to everyday life, connections with other sciences are very weak, different thinking abilities, difficulty understanding learning when studying independently and students really need repetition until understand a problem. Students' skills in using less skilled terms and making sketches/pictures of questions are also still weak.
In the task analysis and the formulation of learning objectives, the researcher found 1 indicator of competency achievement along with the formulation of learning objectives from the

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identification of basic competencies in circle material. The concept analysis is using the concepts contained in the e-handout.

Design

The second stage that must be done is the design (design). The design was carried out to prepare for the implementation using an instrument that was given to students as many as 5 items in which there were indicators of mathematical connection ability on circle material. then realized by choosing media that supports learning and products developed using the Canva application. then choosing a format that follows the standard of the type of teaching material, namely in the form of electronic handouts (e-handouts). In accordance with the initial design of the device then revised by the validator.

Develop

Enter the development stage . Before entering the learning process, researchers tested the validity of the product. The product is tested for validation before it is applied to students. Products are assessed in terms of material, language and media. The acquisition of validity can be seen in table 1.

Table 1. Percentage of Expert Validation Values in Products

Expert validation	Percent validity	validity category
Theory	81%	Very valid
Language	80%	Pretty valid
Media	100%	Very valid
Average Percentage	87%	Very valid

From table 1, it shows that the average percentage reaches a value of 87% with a very valid category. After revising the product which was assessed by the team of experts, the researchers conducted trials twice with different classes to see the practicality, effectiveness and improvement of mathematical connection skills at UPT SMP Negeri 41 Medan.

Trial results I

Trial I was carried out in class VIII-5 UPT SMP Negeri 41 Medan with a sample of class VIII-5 (25 students) by looking at practicality after implementing the learning carried out which can be seen in table 2.

Table 2. Obtaining Student Scores of E-Handout Practicality Questionnaire

No.	Statement per aspect	Percentage
1	Ease of use	28%
2	Efficiency of learning time	13%
3	Usefulness	26%
	Total Percentage	67%

Table 2 shows that the average percentage of student scores from the e-handout practicality questionnaire is 67% and includes practical criteria.

The total scores obtained by the assessment category on the practicality questionnaire from the teacher are:

Table 3. Obtaining E-Handout Practicality Questionnaire Teacher Scores

No.	Statement per aspect	Average percentage
1	Ease of use	64%
2	Efficiency of learning time	80%
3	Usefulness	80%
	Overall average percentage	75%

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Whereas in table 3 the practicality questionnaire generated from the teacher's practicality instrument has an average value of 75%, with the **practical category.**

Based on the classical completeness criteria, the completeness obtained from the mathematical connection ability test carried out in trial I can be seen in table 4.

Table 4. Classical Completeness Level of Mathematical Connection Ability in Trial II

Information	Mathematical connection capabilities	
	The number of students	Percentage
complete	19	76%
Not finished	6	24%
Total	25	100%

Based on table 4, it can be seen that the classical completeness of the mathematical connection ability obtained is that 19 out of 25 students (76%) complete and 6 out of 25 students (24%) do not complete. In accordance with the effectiveness criteria, classical student mastery of at least 85% capable of achieving a KKM score of 72. Thus, the post-test results of the mathematical connection ability in trial I did not meet the minimum criteria of 85%.

If viewed from the level of mastery of students' mathematical connection abilities by using the mathematical connection ability test which has been described as follows.

Table 5. Description of Mathematical Connection Ability Results

Information	Post test Description of Mathematical Connection Ability results
Highest score	100
Lowest value	43.75
Average	83.5

From table 5, it shows that the average result of students' mathematical connection abilities in the post-test results reaches a value of 83.5 .

Furthermore, to determine the achievement of learning objectives can be seen from the post test scores on the percentage of each aspect in students' mathematical connection abilities. Achievement of learning objectives from each aspect can be seen in table 6.

Table 6. Connection Capability Results in Each Indicator

Aspect	Percentage
Connections between math topics	93%
Connection with other sciences	60%
Connection with the real world of students	84.4%

From table 6, it can be stated that the aspect of connection with other sciences has not reached the criteria for achieving learning objectives of at least 75% in category 2, namely connection with other sciences. Thus the results of the post test on the ability of mathematical connections in trial I did not meet the criteria for learning objectives.

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Based on the results of the trial data analysis I, it is known that the developed e-handout is practical but not yet effective, because there is still one aspect of mathematical connection ability and classical completeness that has not been fulfilled. while the effectiveness criterion that was fulfilled was the students' positive response to the practicality of the product.

Trial II

In order to meet the established effectiveness criteria, improvements were made to the product which had not been met in trial I. Trial II was needed in order to get good results. Trial II was carried out in another class, namely VIII-3 at UPT SMP Negeri 41 Medan by looking at the achievement of learning objectives and mathematical connection abilities that did not meet the criteria.

Based on the classical completeness criteria, the mastery obtained from the mathematical connection ability test conducted in trial II is described as follows.

Table 7. Classical Completeness Level of Mathematical Connection Ability in Trial II

Information	Mathematical connection capabilities	
	The number of students	Percentage
complete	22	96%
Not finished	1	4%
Total	23	100%

Based on table 7, it can be seen that the classical completeness of the mathematical connection ability obtained is that 14 out of 22 students (96%) complete and 1 out of 25 students (4%) do not complete. in accordance with the effectiveness criteria, students' mastery learning classically is at least 85% capable of achieving a KKM score of 72. Thus, the post-test results of mathematical connection ability in trial II meet the criteria.

If viewed from the level of mastery of students' mathematical connection abilities by using the mathematical connection ability test which has been described in table 8.

Table 8. Description of Mathematical Connection Ability Results

Information	Post test Description of Mathematical Connection Ability results
Highest score	100
Lowest value	65,6
Average	91.85

From table 8, it shows that the average result of students' mathematical connection abilities in the post-test results reaches a value of 91.85. Furthermore, to determine the achievement of learning objectives can be seen from the post test scores on the percentage of each aspect in students' mathematical connection abilities. achievement of learning objectives from each aspect can be seen in table 9.

Table 9. Achievement of Learning Objectives for Each Aspect of Mathematical Connection Ability

Aspect	Percentage
Connections between math topics	94%
Connection with other sciences	83.7%
Connection with the real world of students	93%

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From table 9, it can be stated that the three aspects of mathematical connection ability have met the criteria for achieving learning objectives of at least 75%. Thus the results of the post test on the ability of mathematical connections in trial II meet the learning objectives criteria.

Based on the results of the second trial data analysis, it is known that the developed e-handout meets practical and effective criteria. because , the achievement of classical completeness and achievement of learning objectives as well as positive responses from students.

Improved Mathematical Connection Capability

The description of increasing mathematical connection ability at UPT SMP Negeri 41 Medan in class VIII-5 and VIII-3 using the STEAM approach with the PBL model. In terms of the two trials conducted, it can be seen that the N-Gain value at the post test trials I and II. The enhancement in the ability of the N-gain value can be seen in table 10.

Table 10. N-Gain Index Mathematical Connectivity Enhancement

Category	Criteria	Trial I		Trial II	
		Amount	Percentage	Amount	percentage
Low	N – Gain < 0.3	4	16%	0	0%
Currently	0.7 >N – Gain ≥ 0.3	7	28%	3	13%
Tall	N – Gain ≥ 0.7	14	56%	20	87%
N-gain		0.666		0.8	
Enhancement		0.134			

From table 12, it can be seen that the N-gain value in trial I reached a value of 0.666 and trial II reached a value of 0.8 . The enhancement experienced from trial I to trial II resulted in an N-gain value of 0.134.

A description of the enhancement in mathematical connection ability in trials I and II for each indicator of mathematical connection ability from the post test is as follows.

Table 13. Average Student Mathematical Connection Ability for Each Indicator

Mathematical Connection Ability Indicator	Average		
	Trial I	Trial II	Enhancement
Connections between math topics	0.93	0.94	0.01
Connection with other sciences	0.6	0.84	0.24
Connection with the real world of students	0.84	0.93	0.09

From table 13, it can be seen that the average mathematical connection ability of students in trial I, namely the connection aspect between mathematical topics was 0.93 ; the aspect of connection with other sciences is 0.6 ; and the aspect of connection with the real world of students is 0.84. In trial II, the connection aspect between math topics was 0.94 ; the aspect of connection with other sciences is 0.84 ; and the aspect of connection with the real world of students is 0.93. For more details, it can be seen in Figure 1.

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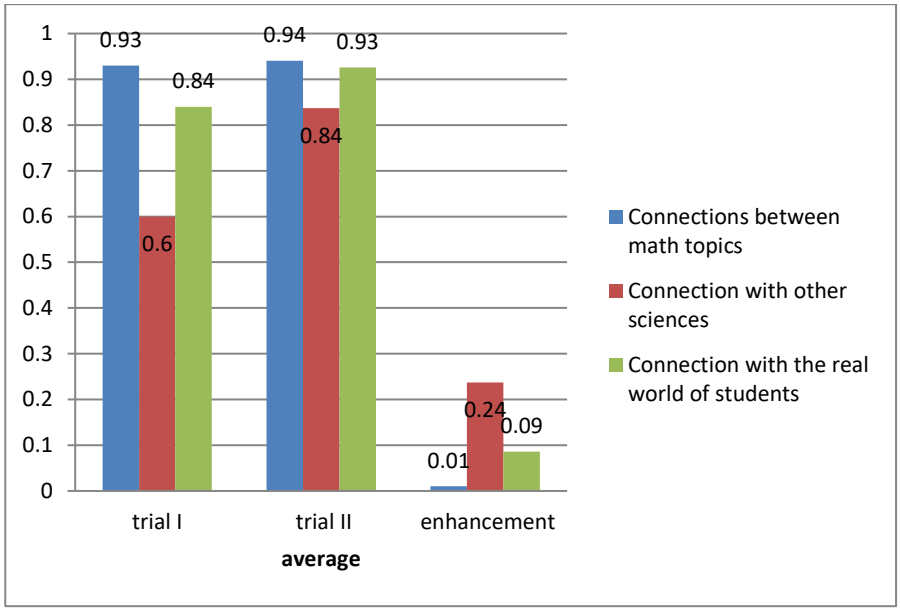

Figure 1. The average mathematical connection ability in each indicator

From table 13 and figure 1 it can be seen that there has been an enhancement in the average of the three aspects of mathematical connection ability between trial I to trial II. In the aspect of connection between mathematical topics, it is 0.01 ; the aspect of connection with other sciences is 0.2; and the aspect of connection with the real world of students is 0.09.

DISCUSSION

After processing the data according to the development of the Thiagarajan model, it is known that the validity of the developed e-handout. According to Sugiyono (2016) before being tested in the field, the product design must go through a validation process for the process of evaluating activities. Product validity is validated by a team of experts from material , language and media with an average percentage of 87%. In the validation there are suggestions submitted by the validator. The material validator is the addition of a discussion about the formula for the area and circumference of a circle in the video. The language validator stated that there was an improvement in the command sentence part for carrying out student activities. The media validator stated that there was an improvement in the title on the cover of the e-handout, alignment of the writing, and the addition of an answer key in the practice questions in the e-handout.

Practicality testing of the product (e-handout) by the teacher and students in terms of the e-handout assessment at the trial stage. The response results obtained were 79% with practical criteria. Thus, it can be concluded that teachers and students have a good response. Furthermore, the effectiveness assessed in trials conducted from learning completeness, achievement of student learning objectives and positive responses. It is known that the results obtained are in accordance with the effectiveness criteria , namely classical completeness. At least students complete classically 85% to achieve KKM, and students are declared complete by obtaining a minimum score of 72. In trial II, 22 out of 23 students (96%) were declared complete. and 1 person out of 23 students (4%) was declared incomplete. it is known that the achievement of the learning objectives of at least 75% is seen from the achievement of each aspect in the students' mathematical connection ability in trial II, which has been achieved with more than 75% of each

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aspect. For this reason, this e-handout is effective to use because of its validity and practical value (Nurhidayat & Asikin, 2021). Based on the findings conducted by Yana, Handoyo, Putra (2021) which are related to the use of digital teaching materials based on the STEAM approach, it has a feasibility level of 87% in the very feasible category.

Looking at the enhancement in students' mathematical connection abilities from the value of n gain using the STEAM-based handout, it was obtained in trial I of 0.666 and trial II of 0.8 . according to Mishra, Henriksen, & the deep play research group (2012) in Danah Henriksen (2014) in using the STEAM approach, users conduct teaching and learning most effectively in connecting art and science as historical evidence. In this regard , STEAM has become an important paradigm for creative and artistic teaching and learning in stem disciplines (Danah Henriksen, 2014). The enhancement that occurred between trials I and II was 0.134. In the N-gain category there are judges from high, medium and low. From the trials conducted, it can be analyzed that in the three aspects of mathematical connection ability ranging from high ability, moderate to lowest, namely:

1. **Aspects of connections between mathematical topics**

High connection ability and moderate connection ability are able to identify between topics to find one answer with answers that are interconnected to get the final result, then indirectly students can connect students' questions and answers with everyday life, and are able to determine and analyze parts by parts in the question item . Two of the three subjects lacked accuracy in answering the questions given starting from the information provided, the process of finding answers, and conclusions from answers.

2. **Aspects of connection with other sciences**

One of the three subjects (low level ability) is unable to solve and understand the problem with the STEAM approach to the PBL model which is related to connections to other sciences, precisely changing the unit of rotation per minute (rpm), the meaning of the trajectory of one full rotation and known information.

3. **The aspect of connection with the real world of students**

Low ability subjects fail to understand the problems of the STEAM approach to the PBL model in everyday life. evident from the completion process carried out by students. It can be seen from the elements in the questions that are not written down, so that what is to be sought hinders the process of determining answers and becomes difficult.

CONCLUSIONS AND RECOMMENDATION

Based on the results of the analysis and discussion in this study, several conclusions were found as follows: 1) The validity of the product developed, namely the STEAM-based e-handout to improve students' mathematical connection abilities which was validated by material, language and media experts was declared very valid by achieving a score 87%, 2) The practicality of the product developed from the practicality questionnaire by students obtains a percentage of 67% and the teacher obtains a percentage of 75%. So the product developed from the two trial responses achieves practical criteria and has a positive response, 3) the effectiveness of the STEAM-based e-handout at UPT SMP Negeri 41 Medan achieving classical student learning completeness (minimum 85%) from the results of students' mathematical connection abilities on the test try II, namely there were 22 students out of 23 (96%) who completed and 1 person out of 23 (4%) who did not complete. the achievement of learning objectives for each indicator of mathematical connection in trial II has met the criteria (minimum 75%), 4) The enhancement in the ability of mathematical connections shows that there has been an enhancement in the average N-gain value from trial I by 0.666 in the medium category and at trial II was 0.8 in the high category and the difference in improvement between trial I and trial II was 0.134.

Based on the research that has been done in developing STEAM-based e-handouts to improve mathematical connections at UPT SMP Negeri 41 Medan, namely the development of STEAM-based e-handouts should use 2 types of learning if it is seen that there are 2 meetings

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written in the RPP so that learning is carried out more optimally and varied. The use of products to create/access products can be sought for alternatives not to use internet quota. It is necessary to conduct similar research using other STEAM-based mathematics so that mathematics learning has references to be able to develop students' cognitive, affective and psychomotor abilities.

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