

PENGEMBANGAN BAHAN AJAR MATEMATIKA UNTUK MENINGKATKAN *CRITICAL THINKING* MELALUI MODEL PEMBELAJARAN *DISCOVERY LEARNING* BERBASIS STEM

Ana Nadhifatul Adnaniyah¹, Dian Noer Asy'ari²,Diyah Ayu Rizki Pradita³

^{1,2,3}Tadris Matematika, Universitas Ibrahimy Situbondo. Jl. KHR.Syamsul Arifin No.1-2
e-mail: ananuuradnan12@gmail.com¹,dianasyari@ibrahimy.ac.id²,diyahpradita@ibrahimy.ac.id³

ABSTRAK

Education is one of the things that become a benchmark in the quality of a nation. To answer the challenges of the times, the Ministry of Education and Culture for Research and Technology held an Independent Curriculum program to create fun learning so as to train students to think critically using the right methods. This research and development aims to produce *critical thinking* teaching materials for students through *STEM-based discovery learning*. The material presented is rows and series of even semesters of class X. The method used is Research & Development by applying the ADDIE development model including, *Analyze, Design, Development, Implementation, and Evaluation*. The research subjects of class X students totaled 34 students. Products developed through validation stages from 2 material experts and 2 media experts to determine product feasibility, Products are tested on learning for effectiveness and reliability tests. The assessment results from material experts obtained a percentage of 82% for material expert preentase and 89% for the percentage of media experts with valid and worthy categories of use. The results of product effectiveness tests using SPSS version 26 showed that the significance level (GIS 2-tailed) was $0.00 \leq 0.05$. So it can be said that there is a significant difference between pretest and posttest scores. The results of student reliability of the product showed a value of $0.907 > 0.60$ with the questionnaire statement for the above variables being reliable and consistent.

Keywords : Mathematics Teaching Materials, *Critical Thinking, Discovery Learning, STEM*

1. INTRODUCTION

Education is one that is used as a benchmark in the quality of a nation. In order to improve the quality of education in Indonesia, the Ministry of Education and Culture for Research and Technology held an Independent Curriculum program in the form of a Driving School which became a catalyst in realizing a generation of lifelong learners and becoming individuals with pancasila character (Rusnaini, 2021). Learning will be fun and diverse so that it can make students trained to think critically, creatively, communicatively and collaboratively requires a suitable method and approach (Astini 2022). The Pancasila Student Profile applied in schools can build the nation's character from an early age and help students understand the values contained in Pancasila and practice them in everyday life is

one of the efforts to improve the quality of education in Indonesia (Dwiningrum, Widagda, and Aditya 2022). In the current era of technological advancement in globalization, the role of values and character is needed to provide a balance between technological developments and the development of human resources (Faiz and Kurniawaty 2022). The Pancasila Student Profile consists of six dimensions, namely; 1) Faith, Fear of God Almighty, and Noble Character, 2) Global Diversity, 3) Independence, 4) Mutual Cooperation, 5) Critical Reasoning and 6) Creative (Syafi'i 2021).

The answer to the demands of the Pancasila student profile which requires balancing education and technology as a medium of communication in learning encourages educators to continue to hone and develop the

ability to think as a provision in facing global challenges in the digital era, a learning approach that is in accordance with the learning demands held by the government is needed (Izzati et al. 2019). STEM (*Science, Technology, Engineering, Mathematic*) is an approach to learning that involves technology in improving the quality of education. STEM-based learning can build creativity and environmental literacy that are indispensable to face the 21st century (Suwardi 2021). Every level of education is required to have development in several skills in critical thinking, creative thinking, communication and collaboration (Septikasari and Frasandy 2018).

The increase in *critical thinking* occurs because the use of the *Discovery learning model* is able to create more conducive learning and requires students to be active in the learning process and develop their own understanding of the material (Rihayati, Utaminingsih, and Santoso 2021). This is in accordance with research (Ruhama and Jamaan 2021) which states that *discovery learning* is the right learning model to answer students' problems about critical thinking skills.

Someone who has the ability to think critically will be very influential in his daily life, which will always make the right and good decisions (Munawwarah, Laili, and Tohir 2020). From the results of published journals, it was found that *Discovery Learning* is learner-centered learning with guidance from teachers in order to make learning a meaningful experience (Asyari 2019). Through meaningful learning students can think about discovering for themselves and communicating with others in concepts, theories, ways, and problem solving found in everyday life.

Teaching materials consist of a series of systematically arranged materials that are fully mastered by students, so that learning objectives are achieved by students and teachers. Teaching materials are a systematic arrangement of all forms of materials containing material used by teachers to be mastered by students according to their needs, and help create an atmosphere / environment for the implementation of teaching and learning activities as a tool in the learning process for students to better understand a concept in the material. Teaching materials made by researchers are a new product or refinement of existing products. By utilizing technology is also able to improve students' critical thinking in the

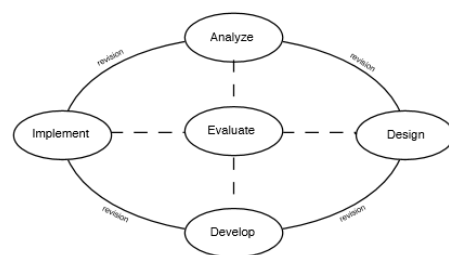
use of existing media. Here researchers choose *Quizizz* interactive media as a learning support.

Based on the problems described above, it can be concluded that it is necessary to develop teaching materials in the form of student teaching materials containing practical activities and projects to improve *Critical Thinking* (Arif, Faiz, and Septiani 2021). and the use of *Quizizz* learning media as interactive media in the use of technology (Anam et al. 2022; Nasution and Nasution 2021). The use of discovery learning learning models as learning supports through learning media.(Faudila, Suastra, and Sujanem 2017) By using the STEM-based *Discovery Learning* learning model which is a solution and waiver for teachers in assignments, assessment of knowledge or skills. This is what encourages researchers to conduct research entitled "Development of Flat Build Material Mathematics Teaching Materials to Improve *Critical Thinking* through STEM-Based *Discovery Learning* Learning Learning Models.

2. METODE PENELITIAN

The ADDIE development model is a learning design model based on an effective and efficient system approach and an interactive process, namely the results of the evaluation of each phase can bring learning development to the next phase (Nichols, Hess, and Greer, 2016). The end result of one phase is the initial product of the next phase. ((Ibrahim, 2011) in Dicka Debby Swastika, 2019). The ADDIE development model (*Analysis, Design, Develop, Implement, Evaluate*) has several steps in its use:

Figure 1. Robert Maribe Branch (2009: 2)



Research is carried out by developing teaching materials as learning companions to improve *Critical Thinking*. This research was conducted at the high school level. The population used in this study was students of grade X. While the sample taken was students in grade X-6 consisting of 34 heterogeneous students.

This research was conducted using T-Test before and after the application of teaching materials as analysis and assessment. To obtain data on validity, effectiveness, and reliability, data collection instruments were used in the form of validity sheets, tests, and student response questionnaires using Likert scales. This Mathematics Teaching Material is validated by consulting experts (S2 Mathematics Education Lecturers and Accompanying Teachers) and determining the validity of the product. As an assessment of product effectiveness, a student response questionnaire instrument is used which includes product attractiveness, ease of product use, *Critical Thinking*, and implementation of *STEM-based Discovery learning*. The following table 1 contains criteria for the practicality of mathematics teaching materials based on the results of student response questionnaires.

Table 1. Validation Questionnaire Answer Conversion Results

Percentage	Category
$0\% \leq \text{skor} \leq 25\%$	Very Not Good
$26\% \leq \text{skor} \leq 50\%$	Not Good
$51\% \leq \text{skor} \leq 75\%$	Good
$76\% \leq \text{skor} \leq 100\%$	Excellent

Data generated from the Pretest-Posttest assessment and student response questionnaires were analyzed and used as a tool to measure product effectiveness.

3. RESULTS AND DISCUSSION

Mathematics teaching materials are a development of learning modules, in this teaching material teaches concept discovery and problem practice. In the development of teaching materials themselves, the development of ADDIE is used, following the flow that has been carried out by researchers.

The first stage is Analysis. *Validate the performance gap*, or seek the truth about problems that become gaps in learning. In seeking the truth of a problem can be seen through learning assessment. In practical terms, there are several possible causes of a gap, namely lack of resources, lack of motivation, and lack of knowledge and skills. The analysis stage in the development of teaching materials includes student characteristics analysis, needs analysis, and curriculum analysis. In the analysis of student characteristics, it was found that students

did not hone students' critical thinking about mathematics lessons and lack of active student performance in learning.

This analysis aims to make the products developed really suit the needs of students. This developed mathematics teaching material is a solution to the above problems. And needs analysis, researchers made observations and interviews with one of the teachers who taught the class. In conducting a needs analysis, the Learning Objective Flow (ATP) in Learning Outcomes (CP) can be analyzed as material to identify the subject matter used in the development of teaching charts. While curriculum analysis is carried out Curriculum analysis is an action carried out after analyzing students, where researchers analyze student demands and needs in implementing curriculum policies that are being pursued. In this case, researchers analyzed the Merdeka Curriculum in order to improve student learning outcomes.

The second stage is *Design*. *Conduct a task inventory*, the purpose of this procedure is to identify the tasks that need to be done to achieve the learning objectives. The concept of task inventory in the context of learning design is a way to identify important items that need to be learned to achieve a specific goal. In this activity, the media will be used in making products that suit your needs. Furthermore, the format design in the product refers to the independent curriculum standards, which are in accordance with CP, TP, and ATP in teaching materials. After completing the format, an initial design is carried out in the form of a cover of teaching materials, author page, preface, table of contents, introduction, learning achievement indicators, instructions for using teaching materials, concept maps, supporting information, motivation, student activities, sample questions, practice questions, summaries, and bibliography.

The third stage is *Development*. In this stage, researchers develop teaching materials through the *STEM-based Discovery Learning* model, where *engineering* and *mathematics* can be applied in it. In addition to the methods developed and poured into the learning design, there are also several stats to improve students' critical thinking skills contained in math problems. The implementation of the learning design can be seen with critical thinking indicators. After being developed according to the results of the analysis, this mathematics teaching material is consulted again with material

	Statistics				Implementasi Discovery learning berbasis STEM
	Kemudahan penggunaan produk	Kemudahan penggunaan produk	Critical Thinking	Hasil Belajar	
N Valid	34	34	34	34	34
Missing	0	0	0	0	0
Mean	6,94	9,56	18,71	3,41	15,79

experts and design experts to be further applied directly to students.

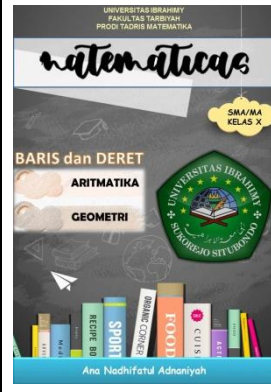
Table 1. Produced products

The fourth stage is implementation, the implementation stage includes the provision of learning materials and resources, preparation of learning schedules, and introduction of students to the new learning environment. In addition, teachers must also prepare themselves to provide guidance and support students during the teaching and learning process. Upon completion of the implementation phase, it is required to proceed to an actual learning environment where students can begin to build new knowledge and skills necessary to close the performance gap.

The last stage is Evaluation, the purpose of the Evaluation stage is to assess the quality of the product and the learning process, both before and after implementation. Upon completion of the evaluation phase, it should be able to identify successes that have been achieved, provide recommendations for the improvement of subsequent projects of similar scope, stop all work, transfer all responsibility for project implementation and evaluation to the administrator or designated leadership, and suspend the design and development team. In the evaluation, researchers conducted Paired *T-test activities* in the form of pretest and posttest results and analyzed the results of student responses. Judging from the results of the Paired *T-Test* test and student responses, it can be stated that the teaching materials developed are declared suitable for use. The following are the results of student responses that show that there is a good response in the use of products and increased *critical thinking*.

Table 2. Results of Anova Analysis of Student Responses

The output table above provides information about the number of data obtained is 34 students, while the missing data is 0, meaning that all data has been processed in SPSS. It can be known that the Mean is the average value of

Product Display	Information
	

several aspects in a row 6.94; 9.65; 18.71; 3.41; 15.79. With a consecutive Std. Error of Mean of 0.13; 0.378; 0.502; 0.127; 0.384.

Student learning outcomes can be measured through pretest before product implementation and posttest after product implementation. This test aims to find out whether the products that have been applied have different power on student learning outcomes.

Table 3. Pre-test and Post-test Results




the sai (Si

table above, it is known that the value of Sig. (2-tailed) is $0.000 < 0.05$, then H_0 is rejected and H_a is accepted. So it can be concluded that there is an average difference between pretest and posttest learning outcomes, which means there is an increase in critical thinking through the STEM-based discovery learning learning model.

In the reliability test, researchers used the same questionnaire questionnaire in taking previous student response questionnaire questionnaire data. The use of the Quizizz application as a learning support is stated to be practical.

Figure 1. Quizizz Apk Usage Results

In the reliability test, researchers used the same questionnaire questionnaire in taking previous student response questionnaire questionnaire data.

Paired Samples Test								
	Mean	Std. Deviation	Std. Error Mean	Paired Differences		t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
				Lower	Upper			
PRE-TEST - POST-TEST	59,58824	7,65593	1,31298	-62,25951	56,91696	-45,384	33	,000

Tabel 5. Hasil Reliabilitas Produk Reliability Statistics

Cronbach's Alpha	N of Items
.907	17

From the output table above, it can be seen that there are N of items as many as 17 pieces with Cornbach's Alpha values of $0.907 > 0.60$, so as the basis for decision making in the reliability test above, it can be concluded that the 17 questionnaire question items for the above variables are reliable and consistent.

4. CONCLUSION

Based on the results of research and discussions that have been carried out, it can be concluded that the teaching materials that have been developed are very effective, valid, and reliable in improving *students' Critical Thinking*. This can be seen from the results of student responses as well as *pretest* and *posttest* results which showed a significant increase of 5%. In addition, the teaching materials that have been developed are also suitable for use in learning mathematics on row and row material. Through the development of effective teaching materials, students can more easily

understand the material taught and improve their critical thinking skills.

This will help students face future challenges and better prepare them to improve their thinking skills in the next level of education. In addition, the significant increase that occurred in the results of this study also shows that the teaching materials that have been developed have a very important value in learning mathematics. With effective teaching materials, students can gain a better understanding of the material taught and improve their ability to apply mathematical concepts in everyday life.

The development of effective teaching materials is very important in improving the quality of mathematics learning. It is hoped that with the development of better and effective teaching materials, students can gain a better understanding of mathematical concepts and improve their ability to face various challenges in the future.

6. REFERENCE

- Anam, Ahmad Choirul, Diyah Ayu Rizki Pradita, Nanda Ayu Indarasati, dan Wardani Wardani. 2022. "Pengembangan Media TaKeru sebagai Media Pembelajaran Berbasis Literasi Matematika." *Jurnal Tadris Matematika* 5(1):47–58. doi: 10.21274/jtm.2022.5.1.47-58.
- Arif, Jira Rastal, Aiman Faiz, dan Lidiya Septiani. 2021. "Penggunaan Media Quiziz Sebagai Sarana Pengembangan Berpikir Kritis Siswa." *EDUKATIF : JURNAL ILMU PENDIDIKAN* 4(1):201–10. doi: 10.31004/edukatif.v4i1.1804.
- Astini, Ni Komang Suni. 2022. "TANTANGAN IMPLEMENTASI MERDEKA BELAJAR PADA ERA NEW NORMAL COVID-19 DAN ERA SOCIETY 5.0." *LAMPUHYANG* 13(1):164–80. doi: 10.47730/jurnallampuhyang.v13i1.298.
- Asyari, Dian Noer. 2019. "KEEFEKTIFAN MODEL GUIDED DISCOVERY LEARNING UNTUK MENINGKATKAN KETERAMPILAN KETERAMPILAN BERPIKIR KRITIS." *Edupedia* 3(2):17–27. doi: 10.35316/edupedia.v3i2.257.
- Dwiningrum, Nawang Retno, Mikail Eko Prasetyo Widagda, dan Angga Wahyu Aditya. 2022. "PROFIL PELAJAR PANCASILA PADA KURIKULUM MERDEKA BELAJAR." 8(2).
- Faiz, Aiman, dan Imas Kurniawaty. 2022. "Urgensi Pendidikan Nilai di Era Globalisasi." *Jurnal Basicedu* 6(3):3222–29. doi: 10.31004/basicedu.v6i3.2581.

- Faudila, N., I. W. Suastra, dan Rai Sujanem. 2017. "PENERAPAN MODEL DISCOVERY LEARNING BERBANTUAN KUIS INTERAKTIF UNTUK MENINGKATKAN PRESTASI BELAJAR FISIKA SISWA KELAS X BKP 1 SMK NEGERI." 7(2).
- Izzati, Nur, Linda Rosmery Tambunan, Susanti Susanti, dan Nur Asma Riani Siregar. 2019. "Pengenalan Pendekatan STEM sebagai Inovasi Pembelajaran Era Revolusi Industri 4.0." *Jurnal Anugerah* 1(2):83–89. doi: 10.31629/anugerah.v1i2.1776.
- Munawwarah, Muzayyanatun, Nurul Laili, dan Mohammad Tohir. 2020. "KETERAMPILAN BERPIKIR KRITIS MAHASISWA DALAM MEMECAHKAN MASALAH MATEMATIKA BERDASARKAN KETERAMPILAN ABAD 21." *Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika* 2(1):37–58. doi: 10.35316/alifmatika.2020.v2i1.37-58.
- Nasution, Widi Harawi Rizqi, dan Amanda Syahri Nasution. 2021. "Quizizz: Science Learning Media in Elementary School in Developing Critical Thinking Skills." *Journal of Science Education Research* 5(1). doi: 10.21831/jsr.v5i1.38592.
- Nichols Hess, Amanda, dan Katie Greer. 2016. "Designing for Engagement: Using the ADDIE Model to Integrate High-Impact Practices into an Online Information Literacy Course." *Comminfolit* 10(2):264. doi: 10.15760/comminfolit.2016.10.2.27.
- Rihayati, Sri Utaminingsih, dan Santoso. 2021. "Improving Critical Thinking Ability Through Discovery Learning Model Based on Patiayam Site Ethnoscience." *Journal of Physics: Conference Series* 1823(1):012104. doi: 10.1088/1742-6596/1823/1/012104.
- Ruhama, Fadlina, dan Elita Zusti Jamaan. 2021. "PENGEMBANGAN LEMBAR KERJA PESERTA DIDIK BERBASIS PENDEKATAN CONTEXTUAL TEACHING AND LEARNING PADA MATERI Matriks untuk Kelas XI SMA."
- Septikasari, Resti, dan Rendy Nugraha Frasandy. 2018. "KETERAMPILAN 4C ABAD 21 DALAM PEMBELAJARAN PENDIDIKAN DASAR."
- Suwardi, Suwardi. 2021. "STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS) INOVASI DALAM PEMBELAJARAN VOKASI ERA MERDEKA BELAJAR ABAD 21." *PAEDAGOGY: Jurnal Ilmu Pendidikan dan Psikologi* 1(1):40–48. doi: 10.51878/paedagogy.v1i1.337.
- Syafi'i, Fahrian Firdaus. 2021. "MERDEKA BELAJAR: SEKOLAH PENGGERAK."