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Chatbot Artificial Intelligence (AI) to Supporting Differentiated Mathematics Learning

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Abstract: Artificial Intelligence chatbots have become famous nowadays because of their ease of use, which is even felt by educators and students. However, the AI chatbot algorithm sometimes does not match what is expected because it is not precise and does not match the prompt. For example, when we type the prompt "basic concepts of mathematical modeling for middle school class VII" there is very little explanation of the basic concepts. The search results provided by AI chatbots are too complex for students who want to learn simple basics. Based on this, this research was carried out with the aim of developing an AI chatbot to support differentiation learning. This type of research is ADDIE model development research which is carried out in five stages, namely analysis, design, development, implementation and evaluation. The results of the research at the analysis stage are that students need learning media that is appropriate to their level of understanding of mathematical modeling material as basic material before studying other material. The results of this analysis are the basis for designing an AI chatbot and bot scenarios to be developed and given to experts, namely educational technologists and mathematics education lecturers. After that, small class trials and large class trials at the implementation stage to get practicality and effectiveness test results in using the AI chatbot. The final stage is evaluation as a process of reflection on the results of AI chatbot development. The research results show that the AI chatbot media developed is valid, practical and effective. Valid criteria with a percentage of 89.7%, practical criteria of 85% and effective criteria of 77.67% in small group trials.

Keywords: chatbot AI, differentiated, mathematics learning.

▪ INTRODUCTION

Changes about the learning process are carried out continuously as a form of improving the quality of education, especially mathematics education. Changes have been made in various aspects from curriculum, learning approaches, learning methods, learning tools to the use of learning technology. In terms of learning technology, there has been a lot of research showing that technology supports mathematics learning in Indonesia which is able to improve students' problem solving abilities (Saputra, Utami, & Purwanti, 2023) and students' learning independence (Yanuarto, 2018). Empirical data from several previous studies (Jayantika & Namur, 2022) shows an increase in the percentage of student learning outcomes from 7% to 19% after using technology in mathematics learning. This shows that technology can support innovation in mathematics learning methods, making them more relevant and effective in the context of education in Indonesia. It cannot be denied that the technology that is increasingly popular today is Chatbot Artificial Intelligence (AI) which can be used in the teaching and learning process (Boussouf, Amrani, Zerhouni Khal, & Daidai, 2024; Gökçearslan, Tosun, & Erdemir, 2024; Sihaloho & Napitupulu, 2024). It's like through the use of an AI chatbot, students are able to interact with their teachers but in the form of online conversations that can be done anytime and anywhere (Yeo, Moon, & Kim, 2024).

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The problem that occurs is that the use of AI chatbots is not able to provide basic information and explanations about concepts in mathematics. This is due to the development of algorithms that are too in-depth and the database is very extensive for the answers given (Dwivedi et al., 2023; Oueslati & Ayari, 2024). For example, when searching on the Chatbot regarding "creating mathematical models for class VII middle school children" the search found is modeling steps using 2 variables or others and examples of questions that are quite difficult for class VII middle school children. It is said to be difficult because class VII middle school students are still in the concrete thinking stage so they still need very basic guidance and practice to create mathematical models. This shows that not all AI Chatbots have the same good algorithms. The quality of a chatbot depends on the development and maintenance carried out by the developer (Chen, Gong, Lu, & Tang, 2022; Johari & Nohuddin, 2021).. Therefore, this research was carried out to develop an AI Chatbot that is adapted to students' thinking stages and the selection of the most basic material, namely modeling the simplest algebraic forms.

This AI chatbot was developed to support differentiated learning activities in classes that implement an independent curriculum. Differentiated learning is carried out by grouping students based on their needs or characteristics such as readiness, learning of style and interest of learning (Herwina, 2021; Tomlinson, 2014). When implemented, teachers may experience difficulties in controlling students with various learning needs, so the use of AI Chatbots via their respective cellphones is believed to be able to help teachers in implementing the independent curriculum. In addition, it is believed that the use of AI chatbots can provide additional support so that teachers can focus more on teaching more complex concepts and direct interaction with students. By monitoring student interactions, AI chatbots can make learning more interactive (Opesemowo & Adewuyi, 2024). Students can interact with the AI chatbot through questions and answers, as well as get more detailed explanations. This builds student involvement and can encourage students to be active in the learning process (Laksana & Fiangga, 2022; Smutny & Schreiberova, 2020).

Several previous research have shown the use of AI chatbots in mathematics learning, including research by (R. Martínez-Téllez & Camacho-Zuñiga, 2023) and the other research from (Cheng, L., Croteau, E., Baral, S., Heffernan, C., & Heffernan, 2024) who researched AI chatbots and students' mathematical critical thinking and they developed AI scaffolding chatbots in learning mathematics and its use of AI chatbots makes students more confident in learning mathematics. In response to research by (Cheng, L., Croteau, E., Baral, S., Heffernan, C., & Heffernan, 2024) similar research was carried out but with the aim of developing an AI chatbot to support differentiation learning.

The choice of material for developing this AI Chatbot is mathematical algebra modeling for class VII students. This topic was chosen because this topic is a basic topic that students need to understand so that students do not experience difficulties later when studying the topics of systems of equations, matrices, linear programs and matrices. Apart from that, this material was chosen because the percentage of the algebra domain at the research school was 54.43%, so more attention was needed to improve students' abilities in Algebra topics. From this description, the aim of this research is to develop an AI Chatbot that meets the criteria of being valid, practical and effective. From this explanation, researchers feel the need to conduct research on how to develop an AI

chatbot that is valid, practical and effective in supporting differentiated learning? So the aim of this research is to develop an AI Chatbot that meets the criteria of being valid, practical and effective.

▪ METHOD

This research is research and development of the ADDIE model. The ADDIE model was chosen because it has systematic development stages according to development needs. The stages carried out in this model are 1) analysis, 2) design, 3) development, 4) implementation and 5) evaluation. The first stage is analysis. At this stage, identification of the need for using technology and analysis of learning materials is carried out. Analysis needs to be carried out to ensure that the product being developed is right on target. The second stage is design. At this stage, the AI chatbot design and Bot algorithm that will be developed for the chatbot are planned. The next stage is the development of an AI chatbot which has been designed to then be tested for validation by experts, namely learning technologists and mathematics education lecturers. An AI chatbot is said to be valid if it is in the minimally valid category. If the AI Chatbot is valid then it can continue to be tested for practicality in small classes of 5 students. An AI chatbot is said to be practical if it is in the minimally practical category. The next stage of development is implementation. At this stage a valid and practical AI Chatbot was tested in a small class of 5 students. The five students were given used the AI Chatbot in learning and then given test questions. This test data is used as data to measure the effectiveness of the AI chatbot. AI chatbots are said to be effective if they are in the moderately effective category. The final stage, namely evaluation, is carried out by assessing the AI chatbot being developed, including any deficiencies that need to be corrected.

This research was conducted during November 2024 on class VII junior high school students. There are several instruments used in this research, namely the AI Chatbot validation sheet, practicality sheet and question sheet. Expert validation sheet to assess AI chatbot designs from appearance design aspects and ease of use aspects. Practicality sheets to assess aspects of students' responses to AI chatbots as well as question sheets to assess the effectiveness of using AI chatbots on learning outcomes before and after use. Validation/practicality and effectiveness analysis uses a range of quantitative scores which are then converted to to qualitative data based on table 1. (Laja & Ahzan, 2024). Quantitative score percentage using a formula

$$\text{Percentage} = \frac{\text{score obtained}}{\text{maximum score}} \times 100$$

Table 1. Data conversion criteria validation/practicality/effectiveness

Score	Qualitative Criteria
$\bar{x} > 76.005$	very valid/ practis/effect
$63.335 < \bar{x} \leq 76.005$	valid/ practis/effect
$50.665 < \bar{x} \leq 63.35$	quite valid/practical/effective
$37.995 < \bar{x} \leq 50.665$	less valid/practical/effective
$\bar{x} \leq 37.995$	very less valid/practical/effective

▪ RESULT AND DISSCUSSION

Stage 1. Analysis

AI Chatbot Needs Analysis

There are not many learning media available mathematics based on an Android application. Apart from that, AI chatbots which are trending lately provide information for free to users. Several problems were found that when searching for mathematical modeling topics using chatbots, there was some inaccurate information regarding the students' needs. For example, if you search on a chatbot regarding mathematical modeling for class VII students, the search results are complex modeling that uses two variables. Therefore, an AI chatbot was developed that students can use via Android cellphone and access anytime and anywhere.

Learning Material Analysis

The AI chatbot displays algebra topics. The topic of Algebra is one of the topics in measuring numeracy competency in an educational unit. The percentage of this topic in the SMPN Neonbat education unit is 53.34%/100. This percentage needs to be improved for the better. In Algebra, there is a basic topic that is most needed, namely the topic of converting real language into mathematical models. Students need to understand this topic to make it easier for students to study other related materials. To support the success of increasing on this topic, supporting media was developed in the form of an AI chatbot.

Stage 2. Design

This stage is the development design stage. The AI chatbot development design was carried out following the messenger-based AI chatbot design flow. Figure 2 shows the appearance of the designed AI chatbot. The AI chatbot begins by designing the bot response flow that is given, namely the opening sentence of the chat - selection of learning activities (learning activity 1, creating a simple mathematical model or learning activity 2, creating a model and solving problems) - example questions - practice questions - selection of learning activities (learning activity 1, making a simple mathematical model or learning activity 2, making a model and solving problems) – example questions – practice questions- finished. More details about the AI Chatbot scenario are explained in table 2.

Figure 1. Desaign chatbot AI

Table 2. Scenario of chatbot AI

Chatbot Scaffolding	Skenario Chatbot
Starting with an opening sentence	Welcome students to this platform, please ask about Mathematical Modeling material
Material Selection	Bot : Activity 1 Material/Example Questions Activity 1/Practice Questions Student Response : Selecting Material or Example Questions or Practice Questions
Activity 1 Material	Creating a simple mathematical model is done by selecting variables, combining them with an operation sign and numbers.
Example of Activity 1 Questions	Example 1. The length increases by 2 cm Alternative 1. Choose a variable, say x. So that the current length is x+2 Alternative 2. The length $\underbrace{\text{bertambah}}_{+}$ + $\underbrace{2\ \text{cm}}_{2}$. Suppose the original length is x, the algebraic form is x+2 Example 2. The length of the rectangle is 8 cm longer than twice its width. Alternative 1. Let w be the width of the rectangle and 2w be twice the width of the rectangle. So, the length of the rectangle is 2w + 8. Alternative 2. The original width of the rectangle is w cm. The length is $\underbrace{8\ \text{cm}}_{8}$ $\underbrace{\text{lebih}}_{+}$ dari $\underbrace{\text{dua kali lebarnya}}_{2w}$ So, the length of the rectangle is 2w + 8. Example 3. A person's age in 7 years Alternative 1. Let t be age. So 7 years in the future becomes t+7 Alternative 2. $\underbrace{\text{Umur seseorang}}_{t}$ $\underbrace{7\ \text{tahun}}_{7}$ $\underbrace{\text{yang akan datang}}_{+}$ So, a person's age in 7 years in the future is t +7
Practice of Activity 1 Questions	1. 2 times a number plus 3 2. Sinta bought some books, then bought 3 more books 3. Shrinked 3 cm 4. 3 days ago 5. 4 years younger 6. The price of granulated sugar this year has decreased by Rp 500.00 from last year 7. Increased 25%

	8. Shrinked 20% 9. 10% cheaper 10. The price has increased by 20% 11. The length of the side of a rectangle is 12 cm more than 3 times its width 12. The minimum height to enter AKMIL is 165 cm. 13. Andi's report card score is 4 less than Udin's score. 14. The air temperature at the top of a mountain is no more than 28◦ C.
Bot Menu	Bot : Back to Home Menu Student Response : Clicking Home Menu
Material Selection	Bot : Activity 2 Material/Example Questions Activity 2/Practice Questions Activity 2 Student Response : Selecting Material or Example Questions or Practice Questions
Activity 2 Material	Modeling and Solving Problems For this, you need to pay attention to several steps to compile an algebraic mathematical model and its solution. 1. Choosing a variable 2. Composing algebraic forms 3. Composing the mathematical model. 4. Completing an open sentence or mathematical model 5. Stating the answer according to what is asked in the problem Checking the correctness of the answer by "returning" it to the original problem
Example of Activity 2 Questions	Example 1. Three consecutive natural numbers have a total of 606. What are they? Solution: 1. Choose a variable Let the natural number be b 2. Arrange algebraic forms Since there are three consecutive natural numbers and the next number is greater than the previous number, then there are b, b + 1 and b + 2 3. Arrange the mathematical model form. Therefore the mathematical model becomes $b + (b + 1) + (b + 2) = 606$ 4. Complete the open sentence or mathematical model $b + (b + 1) + (b + 2) = 606$ $3b + 3 = 606$ $3b + 3 - 3 = 606 - 3$ $3b = 603$ $b = 201$ 5. Stating the answer according to what is asked in the problem The first consecutive numbers that are added are 201. The next are 202 and 203.

6. Checking the correctness of the answer by "returning" it to the original problem. The sum of 201,202, and 203 is 606. The statement and answer are proven correct.

Example 2. A quarter of the size of a natural number and a third of the next natural number total 5. What is the natural number?

Solution.

1. Choosing a variable Suppose x is a natural number, so the next natural number is x+1.
2. Arranging algebraic forms

$\underbrace{\text{Seperempat}}_{\frac{1}{4}}$ dari besar $\underbrace{\text{suatu bilangan asli}}_{\text{x}}$ adalah $\frac{1}{3}\text{x}$

$\underbrace{\text{Sepertiga}}_{\frac{1}{3}}$ $\underbrace{\text{bilangan asli}}_{\text{x}}$ $\underbrace{\text{berikutnya}}_{+}$

Compiling the mathematical model form.

$$\frac{1}{4}\text{x}+\frac{1}{3}(\text{x}+1)=5$$

Complete open sentences or mathematical models

$$\frac{1}{4}\text{x}+\frac{1}{3}(\text{x}+1)=5$$
$$3\text{x}+4(\text{x}+1)=60$$
$$3\text{x}+4\text{x}+4=60$$
$$7\text{x}=60-4$$
$$7\text{x}=56$$
$$\text{x}=\frac{56}{7}$$
$$\text{x}=8$$

Stating the answer according to what is asked in the problem The natural number is 8 Checking the correctness of the answer by "returning" it to the original problem A quarter of eight is 2 added to a third of 8+1=9 is 3 so 2+3=5. The statement and answer match so it is correct.

Example 3. The price of an item after a 20% discount is Rp 100,000.00. How much was the item before the discount?

1. Choosing a *h* variable Let h be the price.
2. Arrange algebraic forms
3. $\underbrace{\text{Harga}}_{\text{h}}$ suatu barang $\underbrace{\text{setelah diberi diskon}}_{-}$ $\underbrace{\underbrace{20\%}_{\frac{20}{100}=\frac{1}{5}}}$ $\underbrace{\text{adalah}}_{\text{h}}$ Rp 100000,00

4. Create a mathematical model

$$\text{h}-\frac{1}{5}\text{h}=100000$$

5. Complete open sentences or mathematical models

	$\frac{5}{5}h - \frac{1}{5}h = 100000$ $\frac{4}{5}h = 100000$ $4h = 500000$ $h = \frac{500000}{4}$ $h = 125000$ 6. State the answer according to what is asked in the problem. The price before the discount is Rp. $125000,-$ 7. Checking the correctness of the answer by "returning" it to the original question The price of goods is Rp. 125,000,- after getting a 20% discount becomes Rp. 100,000,-. So the answer is in accordance with the statement
Practice of Activity 2 Questions	1. My birth date plus 7 will produce a multiple of 9. I was born in the 3rd week of December. My birthday is …. 2. Two fifths of a number is equal to 1 less than three times the number 5. The number in question is …. 3. 3. Mr. Agus has 6 cows less than the number of ducks. If the total number of duck and cow feet is 36, then the number of ducks Mr. Agus has is ….
Bot Menu	Bot: Back to Home Menu Student Response : Clicking Home Menu
Closing Sentence	You have reached the end of the lesson. See you!

Stage 3. Development

The AI chatbot is validated by validators with the positions of learning technology expert and mathematics education lecturer. The validation results are shown in table 3 which, if calculated in general, can be seen in table 4 which shows an average of 78.25 in the very valid category. Next, a practicality test was carried out in a small class of 5 students from class VII SMP. The five students responded well to the AI chatbot, some students even said "cool", or responded "this is the first time learning to use the application". This is enough to provide a good response to the research results. Meanwhile, the results of the practicality test can be seen in table 5 which shows the percentage in the 85 very practical category.

Table 3. Result validation

Aspect	Statement	Score Validator 1 Score	Validator 2 Score	Persentase
Display Design	The display design presented is in accordance with the characteristics of the user or student.	4	4	80
	Design an attractive display for students	4	4	80
	The background on the media has the right color	3	4	70

	Writing symbols/equations in media can represent the learning material presented.	4	4	80
	The menu display on the media makes it easier for users to use the media.	4	4	80
	The menu layout on the media does not confuse users	4	5	90
	Buttons have the right colors and icons	5	4	90
	Buttons have consistent colors and icons	3	3	60
	The font/letters in the text have the correct color	4	4	80
	The font size or letter size is appropriate and suitable for its use (title, content, etc.)	4	4	80
	The type of font used does not confuse users in understanding the information contained.	5	4	90
Average		80	80	
Media Usability	The media is easy to use and simple to operate.	4	4	80
	Media that can be used as independent teaching materials	5	4	90
	Media can be used on various devices	3	3	60
Average		80	73	

Table 3. Validation result of chatbot AI

Validator	**Percentase**		**Average**
	Desaign	Easy to Use Media	
I	80	80	80
II	80	73	76.5
Cumulative Average			78.25

Table 4. Practis result of chatbot AI

Student	**Percentase**
I	85.7
II	89.28
III	85.71
IV	85.71
V	82.14
Average	85

Stage 4. Implementation

At this stage, the researcher only implemented the use of the chatbot in a small class of 5 students who were the same as filling out the practicality questionnaire in the previous development stage. The results of this small class trial are to obtain data on the effectiveness of using AI chatbots in small classes through effectiveness instruments and test question instruments. The selection of this small class subject is based on the characteristics of students who are very ready to receive algebra modeling material. The results of small class trials can be seen in table 5 with an average of 77.67% which shows that the AI Chatbot was very effective in being tested in small classes.

Table 5. Effectivness result of chatbot AI in the small group

Student	Tes Value	Effectiveness	Average
I	55	91.67	73.35
II	72	83.33	77.65
III	50	83.33	66.7
IV	82	88.89	85.4
V	90	80.55	85.27
Average			77.67

Based on all stages of development, researchers observed that there were several improvements as evaluation material for the development of AI chatbots in supporting the implementation of differentiated learning, namely:

1. The content of the AI chatbot needs to be developed based on student needs
2. Ensure users use a strong and stable internet network
3. Increase the number of examples of questions to create a simple mathematical model

The results of this research show that the AI chatbot developed meets the valid criteria with a percentage of 89.7% in terms of material and Bot algorithm (Anum, 2022). The Bot algorithm developed is also simple and easy to understand as evidenced by the practical percentage of 85% and the AI chatbot being effectively used at 77.67%. If viewed from the aspect of the material developed for this AI chatbot, it is very simple, namely about creating mathematical models and solving problems. The availability of lots of questions and practice questions really helps students understand how to create mathematical models from the simplest to the most complex (Lee, D., & Yeo, 2022). The choice of material makes it very important for students to understand mathematical models, considering that most of the word problems in mathematics require the preparation of algebraic models as a form of solution.

This research shows that in terms of implementing differentiated learning, which of course requires more effort and work for teachers, AI chatbot technology plays a quite good role in supporting the implementation of differentiated learning in the classroom (Al Hakim & Setyowisnu, 2021; Go, Lim, & Shin, 2024; Wijaya, Sarosa, & Tolle, 2018). The teacher's job will become younger because the teacher only monitors the use of technology that has been developed and answers additional questions from students. This is in line with other research findings which suggest that technology has a role in supporting learning and motivation (Jaafar, Nor, & et all, 2022), technology makes the teaching and learning process easier to access information (Palancı & Turan, 2021).

Furthermore, the impact of AI chatbot technology can improve students' mathematical thinking abilities (Van Doc, Hoai Nam, Thanh, & Minh Giam, 2023). Another theory found from the results of this research is that AI chatbot technology can support differentiated learning in the classroom, requiring appropriate considerations, for example consideration of material selection or consideration of differences in student characteristics.

▪ CONCLUSION

The results and discussion show that the AI Chatbot to support Differentiated Learning has met the criteria of being valid, practical and effective. Valid criteria with a percentage of 89.7%, practical criteria of 85% and effective criteria of 77.67%. The results of this research are additional findings, especially in mathematics learning, that AI chatbots can improve student learning outcomes in a measurable and then reliable way.

However, this research has shortcomings in that it is a small class trial that may not be generalizable on a large scale. This can cause bias in the results obtained, so there is a need for large class trials. Overall, the results of this research have made an impact on using AI chatbots in differentiated learning, and pave the way for further research to explore the full potential of this technology in improving student learning outcomes.

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