Developing A Differentiated Learning Model Based on Artificial Intelligence : Implementation in The Mathematics Classroom

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Abstract: This study aims to produce a model that can meet the needs of Differentiated Learning based on AI. This method used research and development (R&D) with the Generic Desain Research Model (GDRM). The subject of this study was mathematics education experts and mathematics learning model experts. Instruments used in this study include quality validity assessment and feasibility assessment analysis. The data analysis techniques used were quantitative methods with learning model validity assessment criteria that use A Linkert Scale of 1-4. The test results of the AI-based Mathematics learning model show that (1) the Content Validity test resulted in an average of 3.47 which means the model is very valid, and (2) The average feasibility test is 3.43, which means it is also very valid. The results showed that the AI-based Mathematics learning model can be implemented in differentiated mathematics classes and train students to learn independently, think critically, provide solutions to problems, and have the courage to convey solutions.

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Introduction

In recent decades, rapid advances in technology have affected many aspects of life, including education. Artificial Intelligence Technology (Artificial intelligence = AI) is one of the most famous innovations. AI is a term that refers to computer systems that can perform tasks that usually require human intelligence (Zhang, 2021). In terms of education, AI has great potential to change the learning paradigm and improve the quality of education. In the right portion, AI can help educators and students improve the quality of learning without neglecting social aspects and ethics (Wang, 2023). One of the most exciting topics of using AI is its ability to assist educators in providing differentiated education, which is currently being intensified in the world of secondary education (Fütterer et al., 2023). AI technology enables a customized learning approach for each learner with machine learning and adaptability capabilities (Chan & Hu, 2023). Many positive effects can result from the adoption of artificial intelligence technology in education (Lo, 2023). First, AI can help educators create better teaching strategies by identifying strengths and weaknesses, as well as differences in learning styles, and classifying student personality types that are needed in differentiated learning. Second, AI platforms can make learning more interactive and responsive, creating a dynamic and engaging learning environment.

Chat Generative Pre-trained Transformer (Chat GPT) is one example of the use of AI in education. Chat GPT is a learning tool that learners can use to support their understanding of the subject matter because this technology allows for more natural human language interaction, as well as the ability to answer questions and provide explanations in a timely manner in real-time (Mujiono 2023).

The introduction of AI in education cannot be separated from a number of problems. Some of these are privacy concerns, data security, and inequalities in technology access in various educational environments, especially on the originality or authenticity of the work, which must be given the right signs so that the world of education does not become a source of dishonesty (Nehring et al., 2023). Therefore, clear policies and moral responsibility are needed to incorporate artificial intelligence technology into the school curriculum.

The role of AI in education today is increasingly evident due to the awareness that everyone has different needs, potentials, and learning approaches for everyone and is no longer limited to a one-size-fits-all model. This means that learners with different learning speeds and styles may need more support. From this awareness emerged the concept of differentiated learning in response to needs with an emphasis on diversity and personalization of learning experiences. Differentiated learning is a method that recognizes differences in learning styles, levels of understanding, speed of understanding, and interests of learners. The ultimate goal is to create a learning environment that meets the needs of every learner and helps them reach their best potential (Wahyudi et al., 2023).

Each student has their uniqueness in learning mathematics, for instance, research based on personality types (Sunarto et al., 2017) reveals that there are many differences when solving problems, such as the sequence of reading questions for each personality being different, as well as the methods of solving them. These differences can be highly disruptive if educators do not understand and enforce the same methods for all students. In the world of mathematics education, which is often considered not easy, paying attention to the differences in each individual is very necessary, so differentiated learning is essential for several reasons, among them the way everyone understands and processes data differently (Kaluge & Halimi, 2023; Saleh, 2021). Differentiated learning makes it possible to appreciate diversity.

In addition, it is also helpful to increase interest in learning and reduce the risk of student boredom, so educators must be able to create learning methods that adjust to the abilities, learning styles, and personalities of students (Hapsari et al., 2018). Appropriate learning methods will help each student reach his or her full potential, as well as minimize gaps in academic achievement, simply because students need to get the appropriate learning tools. Differentiated learning has several principles, namely (i) educators must understand the needs of each student in terms of abilities, learning styles, and personality types, (ii) educators must be willing to use several learning models tailored to the needs of students, (iii) educators will conduct continuous and continuous evaluations in order to recognize the needs of students better, (iv) collaborative learning is needed, so that students can appreciate the uniqueness of each so that the strengths of one learner can be used to reduce the weaknesses of other learners.

Some learning methods that are appropriate to differentiated learning are (i) Case Based Learning (CBL) and (ii) choice-based assignment, with multiple options that allow learners to complete tasks as per learners' needs (Sulistianingrum et al., 2023). At its core, differentiated learning is not just about understanding the needs of learners but also helping them grow and develop as unique individuals. By implementing these ideas, education becomes more inclusive and empowered, which brings long-term benefits to the development of every learner (Abu Hassan & Ajmain, 2022). In particular, mathematics learning plays a role in educating students' logical and analytical thinking, of course, it is very well known that each student's way of thinking is very different. Problem-solving in mathematics can be diverse, and educators must be able to understand this and not assume that different ways of solving mean wrong (Hidayati, 2020). So it can be said in summary, the advantages of

differentiated learning are (i) recognizing the diversity of learners, (ii) personalizing learning, (iii) increasing student engagement, (iv) reducing academic gaps between students with one another, (v) better able to motivate students, (vi) inclusive and diversity-friendly.

Cased-based learning (CBL) becomes a suitable learning model for mathematics learning (Asfar & Asfar, 2020a). This is because (i) with CBL, being able to engage learners in real-world cases can help them understand the relevance and practical application of mathematical concepts, (ii) Learners are more motivated to learn mathematics because they can see how the subject matter relates to situations they encounter daily, thus increasing their understanding of the material and providing more apparent objectives for learning the concepts mathematics. (iii) CBL encourages learners to do active problem-solving. Not only do they learn formulas or rules, but they also learn how to apply those ideas in real situations (iv) Through CBL, Continuous learning can be achieved through complex and varied cases. Learners can deepen their understanding over time through an increasingly complex or varied set of cases (Dewi & Nurjanah, 2022). This method of education improves problem-solving skills. This research is important to help educators prepare differentiated mathematics learning with the help of AI so that differentiated mathematics learning can be implemented. The primary purpose of this study is to build a differentiated mathematical learning model with AI technology that meets the valid requirements both in terms of content and construct and is suitable for use by students based on expert opinions.

Research Method

This learning model is prepared with GDRM (Hariadi & Sunarto, 2023; Plomp, 2013) development research model by Wademan. According to Plomp (2013), GDRM development steps consist of problem identification, tentative identification of product and design principles, tentative theory and product, developing prototypes and assessing products, and improving product quality. The procedures consist of:

1) Preliminary Research, in the form of a literature review of the types of AI technology for learning, learning styles, and personality classifications, as well as the abilities to train students,

2) Compiling five model-making procedures, namely Model Syntax, Social System, Reaction Principle, Support System, Instructional impact, and accompaniment impact,

3) questionnaire to measure quality (construct validity and content validity), as well as feasibility measurements,

4) Model revisions according to test results.

According to (Asfar & Asfar, 2020b), quality in the measurement of learning models means that it is valid in content and construction and is considered feasible by learners to improve their abilities through the help of the latest technology (Rohyana et al., 2023). In this study, the main product is an AI-based mathematical learning model in the form of a model book. This type of research is development research that adapts the Wademan model development research design (Hariadi et al., 2021). The subject of this study was a group of students in the Basic Mathematics Course in the Information Systems study program at a university in Surabaya.

Expert validation is needed for validation related to content and constructs to be carried out in the draft learning model and for feasibility to be used by students. There are three mathematics education experts and mathematics learning model experts as samples in this study who will be involved as users in this mathematics learning model with AI. Through the Questionnaire, the three experts will assess the validity of the content, namely the need for interventions and designs based on current knowledge, as well as construct validity,

namely the assessment of the fulfillment of logically designed interventions. The results of this expert assessment are used as a reference for revising the draft model.

In addition to validating both content and constructs, an assessment of the feasibility of AI-based mathematics learning models was also carried out, which was filled by experts in mathematics learning (Dewiyani Sunarto & Hariadi, 2022). The results of this expert assessment will be used as a reference to revise the draft AI-based mathematics learning model. The questionnaire data was then analyzed using descriptive statistics using average scores from expert assessment results. The average score criteria use single measures of Interrater Coefficient Correlation (ICC) and Cronbach's Coefficient Alpha as Table 1 below:

Table 1. Learning Model Validity Assessment Criteria

Score Interval	Judging Criteria	Information
$3.30 < P \leq 4.00$	Highly Valid	Can be used without revision
$2.30 < P \leq 3.30$	Valid	Can be used with minor revisions
$1.80 < P \leq 2.30$	Less Valid	Can be used with multiple revisions
$1.00 < P \leq 1.80$	Invalid	It cannot be used without revision and still requires consultation

Adoption: (Prahani et al., 2023)

This criterion will be used to analyze the AI-based mathematical learning model that has been developed by researchers.

Results and Discussion

The AI-Based Mathematics Learning Model is built based on theoretical thinking of learning model design and the purpose of model development, namely preparing skills in Society 5.0. The development of AI-based Mathematical Learning Models is based on several learning theories, understanding of AI technology, an understanding of differentiated learning including the classification of personality types and learning styles. All factors supporting the development of this learning model can be seen in Figure 1.
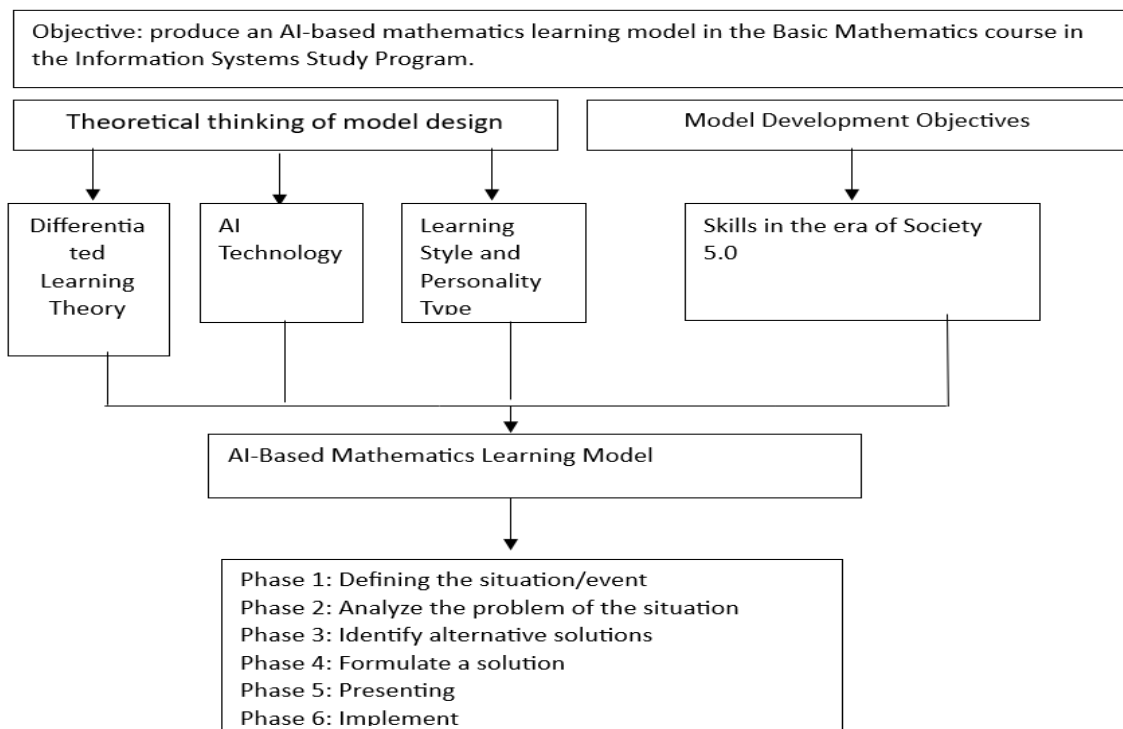

Figure 1. Rationality of AI-Based Mathematical Learning Model Development

By combining the understanding of several concepts above and referring to the characteristics of the field of mathematics that leads to solving problems through case studies, six phases of the *AI-Based Mathematics Learning model are* obtained, namely (1) Defining situations/events, (2) Analyzing problems from situations, (3) Identifying alternative solutions, (4) Formulating solutions (5) Present, and (6) Implementation where each phase optimizes the utilization of AI to find solutions to problems.

Type *AI-Based Mathematics Learning* divides time into 60% of learners learning independently and learning with other learners and 40% of learners learning with educators and other learners (Benlahcene et al., 2020; Gonçalves & Capucha, 2020). Of the 60% of students learning independently and with other students, it is expected that the skills needed in the era of Society 5.0, such as Independent Learning to overcome VUCA problems and the ability to collaborate with other students, are needed in the era of Society 5.0. With many opportunities for students to discuss, do literacy, work in groups, and find the best solution to a problem, the skills needed in the era of Society 5.0 can be adequately honed. The remaining 40%, it is still needed students to meet directly with educators and other students in large groups to get reinforcement, affirmation, and determination of the best solutions to be implemented, as well as some human touches that can strengthen their ability to interact and make the best decisions.

For mathematics learning to be more optimal, educators must have creativity in optimizing AI to support learning, which can be used to prepare students to face the era of society 5.0. The completeness that must be met for this learning model is (1) Semester Learning Plan (RPS), (2) Learning Object Material (LOM), and (3) Evaluation, all of which are according to learning style or personality type and AI-based according to each need.

Five main components of the learning model, according to Bruce R. Joyce (Salija & Rahman, 2022): (1) syntax, which is a sequence of learning known as phases; (2) social systems, which include the roles of educators and learners and necessary norms; (3) the reaction principle, which teaches educators how to see and respond to learners' actions; and (4) support systems, which include necessary conditions and requirements. *Instructional impact* is the learning outcome achieved directly by the teacher by directing students to the expected goal. In contrast, the accompaniment impact is another learning outcome produced by the learning process and causes students to experience direct learning experiences without direct guidance from the educator.

Syntax of AI-Based Mathematics Learning Models.

In general, the learning model is a process of reciprocity between students and teachers as well as between students themselves (Gustina et al., 2023). In learning with the *AI-Based Mathematics Learning model,* there are 6 phases, namely: defining situations/events, analyzing problems from situations, identifying alternative solutions, formulating solutions, presenting, and implementing. The description of the syntax, along with the skills trained to achieve what is desired in this learning model, can be described as follows:

Phase 1: Defining the situation/event

Phase 1 is the first phase when students start learning mathematics. In this phase, educators strive to introduce mathematics learning outcomes so that they become a reference for each learning process. In this phase, educators also explain problems that often arise and can be solved by solving mathematics through case studies. Phase 1 is more aimed at attracting interest, focusing students' attention, and motivating them to play an active role in learning (Khalil & Elkhider, 2016). To start learning, educators provide case studies in the

form of situations or events to be solved by students in groups. In phase 1, educators also form groups consisting of 4-5 students.

Phase 2: Analyze the problem of the situation

This phase aims to collect information in a structured manner with the help of Student Activity Sheets (LKPD) that educators have made. Through the process of collecting this information, participants and learners can benefit from AI. All data obtained from Chat GPT is a thinking tool that is used as a matter of discussion in groups. The role of LKPD, which is right on target, is proven to increase the goals to be achieved by educators (Bariyah, 2018; Simbolon et al., 2018; Wardani et al., 2018). The role of the educator is to guide students in carrying out step-by-step investigations/problem-solving using AI as a thinking tool to find explanations and solutions to train critical and creative thinking through scientific activities/investigations. Guidance can be done gradually; if it is felt that students are reliable, it is necessary to try project assignment activities without the guidance of educators to train *Independent Learning.*

Phase 3: Identify alternative solutions

This phase aims to train learners in exchanging ideas together to find and identify the best solution. In this phase, students conduct analysis and identify alternative solutions that will be discussed and concluded from the results of the assessment. Critical and creative thinking skills can also be developed in this phase because students are encouraged to optimize in identifying alternative solutions from various incoming data to answer problems in phase 2. Through the identification of alternative solutions, students' critical and creative thinking skills to solve problems will constantly be honed (Tanudjaya & Doorman, 2020).

Phase 4: Formulate a solution

Objective: To assist learners in formulating solutions from existing cases and making conclusions from the results of identifying alternative solutions in various representations to solve problems. In this phase, the task of the educator is to direct so that students can choose the best solution as an answer in formulating a solution. The ability of independent learning students will be improved in this phase because students are encouraged to optimize in analyzing alternative solutions from AI to answer problems in phase 3.

Phase 5: Presenting

Objective: to train students to dare to convey the results of their thoughts in a bigger forum. In this phase, students re-examine the solutions offered, which are then presented in front of the class to inform others (or other groups) of the results of the solution formulation made by the group. It is also a means of informing other groups of proposed solutions. Through presentations, students will be trained to be able to express their thoughts and practice discussion using their critical and creative thinking skills (Koleva et al., 2018; Riadil, 2020)

Phase 6: Implementation

Phase 6 aims to provide the best solution to the problems that arise to be implemented. In this phase occurs the process of determining the best solution for implementation. Group Participants Educate others and offer solutions as answers to problems. The task of the educator is to provide triggers so that learners can choose the best solution offered by each group. Next, select the best solutions that are mutual to be implemented by all groups as problem-solving. Educators see the work of learners as evidence of learning and facilitate follow-up learning through the provision of follow-up assignments needed to corroborate learning outcomes (Sajidan et al., 2020).

Table 2. Time Allocation for Application of AI-Based Mathematics Learning Model Syntax

Phase	Indicators	Time Allocation
1. Defining situations/events.	Direct instruction	15% of learning through situation direction and overview from educators to prepare for independent learning
2. Analyze the problem of the situation.	Creative Thinking and Independent Learning	60% learn independently and communicate with other learners
3. Identify alternative solutions.	Critical Thinking and Independent Learning	
4. Formulate a settlement.	Critical and Creative Thinking and Independent Learning	
5. Present.	Critical and Creative Thinking	15% learning with educators
6. Implementation.	Critical and Creative Thinking	10% learning with educators

From Table 2, the syntax design of the *AI-Based Mathematics Learning Model* allocates time for students to take on roles as much as possible, namely by independent learning and discussing with friends and educators. This is the application of the concept of active student learning that has been widely used in the world of education. The novelty of this learning model is the use of AI as a critical thinking tool. With this learning model, students wait to take AI results as truth immediately, but they test with scientific thinking processes. Thus, all existing information technology will maintain the ability of students' thinking processes because information technology is used as a thinking tool to obtain better results.

AI-based Mathematical Learning Model Validation Results

Quality validation results of AI-based mathematical learning models for quality validity and content validity.

Table 3. Results of Analysis of Quality Validity Assessment of AI-Based Mathematics Learning Models

Content Validity	Validity Score	**Judging Criteria**
The novelty of the benefits of AI-based Mathematics Learning Models for the world of mathematics education	3.58	Highly Valid
The concept of thinking the creation of an AI-based Mathematical Learning Model	3.46	
AI-Based Mathematics Learning Model Development Requirements	3.45	
Description of AI-Based Mathematics Learning Model	3.35	
Construct Validity	**Validity Score**	**Judging Criteria**
Provisions for how to develop AI-Based Mathematical Learning Models	3.44	Very valid
The description of AI-Based Math Learning Model	3.50	

Table 3 shows that the validity of the quality of the AI-based mathematics learning model for content validity has been stated by experts with an average score of 3.46 or is in the assessment criteria is very valid. In contrast, the construct validity reaches an average

score that is almost the same, which is 3.47, so the quality validity for this AI-based mathematics learning model stated in the assessment criteria is very valid.

Furthermore, the feasibility results of AI-based mathematical learning models can be seen in Table 4.

Table 4. Results of the Feasibility Assessment Analysis of AI-Based Mathematics Learning Models.

Feasibility Assessment	Validity Score	Judging Criteria
Formulation of Instructional impact and accompaniment impact	3.46	
Clarity and interconnectedness of support systems	3.34	
Clarity and interconnectedness of social systems	3.35	Very valid
Clarity and understanding of reaction principles	3.45	
Formulation of learning objectives	3.53	

Table 4 shows that the Feasibility Assessment for AI-based mathematical learning models can be categorized on the Very Valid criteria, with the average validity score being 3.43. From the results of the feasibility assessment, the AI-based mathematics learning model can be applied to mathematics learning.

After the quality validity test and feasibility test get very valid criteria, the next step, which are Instructional Impact and Accompaniment Impact, Support System, Social System, and Reaction Principle be described for preparing the model.

Instructional Impact and Accompaniment Impact

According to (McLaren et al., 2022), a learning model is considered adequate if it can generate and achieve pre-set goals. The instructional impact of this model is to help educators prepare differentiated learning so that each teaching device suits their learning style and personality type and helps students expand and deepen their understanding of the material being learned through the help of AI applications. The accompaniment impact is the ability to expand knowledge on a particular material and develop it with its understanding for students and awareness to not only copy but also develop a knowledge and awareness of honesty.

Support System

All tools, materials, and systems needed to apply AI-based Mathematics learning models, including Syllabus, RPS, RPP, LKS, and Student Worksheets, as well as evaluation instruments to evaluate students' critical and creative thinking skills and their independence in learning. In addition, internet networks, AI applications, and videos—both found on the Internet and created by educators themselves—are support systems that help students prepare themselves for the era of Society 5.0. Generation Z needs technology-based learning that is compatible with technology-based learning (Sunarto, 2021a, 2021b).

Social System

Vygotsky's theory of Constructivism shapes the social system used (Lasmawan &; Budiarta, 2020). This social system creates relationships between students and educators. This AI-based mathematics learning model places greater emphasis on the ability of learners to develop their own knowledge through AI applications and understand the skills and needs that exist in the era of society 5.0. Through learning activities, educators value students according to their abilities, learning styles and personality classifications. Every stage of learning is enjoyed by students because it is in accordance with their conditions. In addition, unconsciously, learners are trained to solve problems critically and creatively through search queries using AI applications.

Reaction Principle

The principle of reaction is very important for how learners interact with each other. This includes how learners leverage AI applications and use critical and creative thinking to discuss with each other (Yerimadesi et al., 2019). Educators activate students through various AI applications that can be used to increase knowledge. Educators emphasize the importance of building capabilities in the era of society 5.0.

Advantages of AI-Based Math Learning Models

With the AI-based mathematics learning model, there are several benefits, including AI can see the learning style and learning ability of each student and use this data to create learning plans tailored to the needs of students to help students learn better and at a level that suits their abilities. In addition, AI can create interactive and engaging educational materials(García-Martínez et al., 2023; Romero-Rodríguez et al., 2023). For example, AI-based math apps can make learning more fun and challenging through simulations, games, and in-depth exercises. Another advantage is that AI can aid project and collaborative learning by giving learners the tools and resources to work together on math projects. This can improve the social skills and critical thinking abilities of learners.

Conclusion

Based on the results of the research, it can be concluded that the AI-based mathematical learning models had an average feasibility test of 3.43 and an average content validity of 3.47. Thus, in terms of substance and construction, the quality of AI-based mathematical learning models is legitimate based on expert judgment. The findings of this study suggest that differentiated mathematics learning can be enhanced by using high-quality AI-based mathematical learning models. The efficacy of the AI-based mathematical learning models in raising student learning results in differentiated mathematics learning can be the subject of future investigation.

Recommendation

From the results of developing differentiated mathematics learning models, recommendations can be given to mathematics educators to utilize AI-based learning models to accommodate all differences, ranging from abilities, learning styles, personality types, and other variances. As for policymakers, it is advisable to establish a team to provide teaching aids for educators, enabling them to focus more on the teaching process.

Acknowledgment

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