

Developing a chatbot in quantities, denomination, and measurement: an artificial intelligence-based teaching materials

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Abstract

Keywords:
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Intelligence;
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The material of quantities, denomination, and measurement which are considered less interesting and difficult to understand. This is due to the content and structure of the material which does require prior knowledge to be understood so it seems difficult and a lot of prior knowledge and many abstract concepts. Based on this study, the solution that can be given is to develop a digital-based teaching material for science subjects in the form of a Chatbot. This study aims to develop a chatbot as a digital teaching material based on artificial intelligence in quantities, denomination, and measurement material. This research is development research using the 4D model. Data were collected using test and student response questionnaires. Data analysis using descriptive and inferential statistic. The developed chatbot validated by experts in terms of material, software, and language. The chatbot developed was then disseminated to 65 PGMI IAIN Pontianak students. Based on the results, it can be concluded that the chatbot of quantity, denomination, and measurement material has high validity. The result showed that students' give the positive responses about the display, content and utilization of the chatbot. Based on the results of the calculation of N-gain obtained the result of 0.3. This means that the effectiveness of using chatbot is in the medium category. Therefore, this chatbot quantity, denomination, and measurement material is suitable for use as teaching material in college level.

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Introduction

The Indonesian government has taken significant steps to enhance the cultivation of 21st-century skills. Higgins (2014), states that the curriculum for 21st-century education should not only include critical thinking and 21st-century skills but also fit the specific needs of students in diverse cultures and the particular technical and historical demands of the digital age. By adopting the 2013 curriculum, which places a strong emphasis on fostering the 4C skills (critical thinking, collaboration, creativity, and communication) during the learning process, there is an optimistic outlook that educators will be able to nurture and develop these essential skills in students (Hairida et al., 2020). With the advancement of science and technology, digital teaching materials should now be easily accessible to students through digital teaching

materials. The definition of digital teaching materials is a format of subject matter content that can be accessed by digital devices. Digital-based teaching materials have been developed and found to be valid, practical, and effective in supporting the science learning process. The use of digital teaching materials, such as flipbooks and electronic materials, has been shown to optimize the learning process and increase student motivation (Fahlevi & Maghfiroh, 2023; Sundari et al., 2023; Zainulloh et al., 2022). The use of digital-based teaching materials can support the science learning process.

The use of digital-based teaching materials like chatbots in elementary schools has proved giving a good response from the students (Istiqomah et al., 2023; Kasmayanti et al., 2023; Selvina et al., 2023). The majority of higher education students possess a smartphone, leading to their frequent engagement with internet-based applications (Okonkwo & Ade-Ibijola, 2021). However, based on interviews with several teachers, the use of digital-based teaching materials at the madrasah ibtidaiyah teacher education study program in IAIN Pontianak is still not optimal, especially in science subjects. This is in line with Fatmawati & Sujatmika (2018), who found that In reality numerous science teaching methods in schools remain ineffective, and the utilization of technology as an instructional tool is limited. Iswari (2020), also found that a lack of interest in reading makes students often unable to follow the lesson well because they do not understand science, especially the material of quantities, denomination, and measurement which are considered less interesting and difficult to understand. This is due to the content and structure of the material which does require prior knowledge to be understood so it seems difficult and a lot of prior knowledge to be understood so that it seems difficult and many abstract concepts. The measurement process itself is complex, involving considerations of instruments, accuracy, and potential errors (Basdevant, 2023).

To address the challenges in science education, a viable solution is to create digital teaching materials specifically designed for science subjects. One effective approach involves the development of a Chatbot which can offer interactive and personalized learning experiences for students. This innovative solution not only enhances engagement but also provides a dynamic and accessible way for students to grasp complex scientific concepts. A chatbot is a technology that merges artificial intelligence (AI) and natural language processing or other techniques, enabling it to engage in text or voice-based conversations with a human user to a certain extent (Pérez et al., 2020). According to Deng & Yu, (2023), chatbots can perform three roles in education, i.e., teaching assistants, learning partners, and personal tutors.

Chatbots work by matching questions from users with the help of machine learning. Chatbots are also used in the field of education. Chatbots can be intelligent tutors for online learners. Chatbots have the ability to analyze natural language and this reflects the accuracy of the conversation. When the conversation flow is accurate, it makes the Chatbot an educational tool. For example, chatbots are able to solve problems and provide support in parallel for 100 students individually (Doshi et al., 2017). In addition, this Chatbot can save time, self-study, and answer questions that are difficult for users to find (Dahiya, 2017). Deng & Yu (2023), also states that according to the meta-analysis, chatbot technology had positive effects on various learning outcomes. Specifically, chatbots significantly improved explicit reasoning, learning achievement, knowledge retention, and learning interest, Therefore, researchers are interested in developing an Artificial Intelligence-based Chatbot teaching material. This research aims to

develop a teaching material in the form of a chatbot at the university level, which is expected to facilitate students in learning concepts. By using this chatbot, students will be facilitated in choosing the concept of unit magnitude and measurement that they want to learn.

Method

This development uses the Four-D development research model initiated by Thiagarajan et al., (1974). The stages of this development include 4 stages, namely *Define*, *Design*, *Develop* and *Disseminate*. This model was chosen in developing learning tools because it has the right stages and systematics to develop multimodal teaching materials (Thiagarajan et al., 1974).

The *define* stage is carried out with several activities such analyzing the development objectives, namely producing multimodal teaching material products, analyzing classes that aim to find out the characteristics of students and the difficulties they experience, studying curricula and textbooks, and theories that support development. The details of the products produced are based on the findings of the study results.

Activities carried out at the *design* stage include collecting teaching materials such as learning videos, drawings and additional information, processing and compiling multimodal teaching materials, drafting teaching materials and compiling and finally converting the resulting teaching materials into APKs which will then be tested for feasibility, practicality and dissemination.

The questionnaire instrument for the validity of the feasibility of teaching materials was developed using the Likert scale containing aspects of curriculum suitability, meaningfulness in learning and display using positive and negative statements in accordance with the opinion of Sugiyono (2010). The validity test was carried out by two validators for each aspects; software, content, and language. The instrument is then given an assessment score which includes highly eligible (4), eligible (3), not eligible (2) and highly not eligible (1).

The chatbot developed then disseminated to the Madrasah ibtidaiyah teacher education students class of 2022 using pretest-posttest control group design, The effect was assessed by applying the treatment to the experimental group and not applying it to the control group. (Creswell, 2016). The respondents were selected using purposive sampling technique. The consideration in the selection of respondents is the similarity of lecturers who teach basic science concepts, so classes 3D were chosen as control group and 3E as experiment group with a total of 65 students. To determine the effectiveness of the product through the calculation of normalized gain (N-gain) with the formula:

$$NGain = \frac{S_{post} - S_{pre}}{S_{Max} - S_{pre}}$$

The calculated data is then translated into categories: high(N-Gain ≥ 0.7), medium($0.7 > N$ -Gain ≥ 0.3), and low (N-Gain ≤ 0.3) (Hake, 2013).

Results and Discussion

This research aims to create digital educational resources through a chatbot for effective science learning in the madrasah ibtidaiyah teacher education study program in IAIN Pontianak. The product's validity was assessed via validation and field trials. The development followed the 4D model by Thiagarajan et al. (1974), encompassing four stages as follows:

Define Stage

The defining stage, which is the first part of this research, principally entails a needs analysis. When developing a product, designers must take into account the requirements for development, analyze the data, and gather information on how much development is required. A science lecture from the madrasah ibtidaiyah teacher education study program in IAIN Pontianak was interviewed during this phase. The results of the interviews showed that, in addition to conventional textbooks, the classroom had an LCD projector to aid in teaching and learning. However, the use of PowerPoint tended to promote teacher-centered learning. This, in turn, resulted in low-quality learning outcomes and disengagement among students. As a result, there is a need for creative learning strategies to engage students and make use of non-traditional teaching resources. Based on the results of the interview, the teacher explained that this Scientific material, especially the material of quantities, denomination, and measurements, is quite difficult for students to understand. This is consistent with the study by Fitriani et al. (2021), which discovered that students' comprehension and learning outcomes of quantities, denomination and measurements content were still rated as "sufficient".

In order to help students comprehend science content that calls for a grasp of abstract concepts, a technology like digital teaching materials is required. Integrating technology in science education has significant positive impacts. First, technology such as digital devices and educational software, can be used to provide interactive learning experiences for students (Junger et al., 2023). The use of technology enhances student learning by providing easy access to rich and interactive educational resources. Secondly, it is proven to improve students' academic performance by providing more engaging and real-world relevant learning methods. Educational technology can simulate real-world situations by providing students with tools and platforms that replicate the tasks and challenges they will encounter in professional settings. This allows students to practice and apply their skills in a controlled environment (Younas et al., 2023). Third, The use of technology in education has been found to significantly improve student learning outcomes, especially in developing cognitive skills and critical thinking (Suyuti et al., 2023). In addition, through technology, students can more easily retain the science concepts they learn, as the use of visual and interactive elements helps reinforce their understanding for a longer period of time. As a result, the integration of technology in science education not only enhances students' learning experience, but also contributes positively to their academic development and intellectual skills.

In designing educational activities with digital resources, Churchill (2017) stated that it is necessary to consider several important factors, including clear learning objectives to align the use of digital resources with educational goals, actively engaging students with digital resources to promote interaction and participation, ensuring accessibility of digital resources for all students by taking into account factors such as device compatibility, internet access, and accommodation for students with disabilities, selecting digital resources that match the chosen

pedagogical approach such as inquiry-based learning, problem solving, or collaborative learning, planning the sequence of activities and providing appropriate scaffolding to guide students' development and support their understanding of the content, incorporating assessments that match the learning objectives and provide timely feedback to students on their progress and understanding, and considering technical aspects such as reliability of the digital resources, ease of use, and compatibility with the learning environment.

Design Stage

The first steps in this stage are drafting instructional materials, gathering resources, and generating quiz questions. Then, developing a general layout design, also known as a storyboard or blueprint, look for backgrounds, assemble information pertaining to numbers, units, and measurements, and use supporting graphics, typefaces, animations, and buttons found in chatbot educational materials. A blueprint is important in the process of developing teaching materials because it provides a guide for the design and organization of the curriculum (Qin, 2022). The researcher created a storyboard before creating a questionnaire to evaluate chatbot instructional resources. There are two different kinds of this questionnaire: one is intended to gauge the viability of chatbot instructional materials, and the other is a student response questionnaire. The questionnaire for the feasibility of chatbot teaching materials is made to assess the feasibility of a teaching material that has been developed. The feasibility assessment tool for chatbot teaching materials is divided into three parts, namely the self-efficacy assessment tool, the software efficacy assessment tool, and the language efficacy assessment tool. The student response questionnaire aims to look at students' feedback on the chatbot teaching materials with three indicators including appearance, content, and usability.

Questionnaire then validated by two experts. Taherdoost, (2016) states that validating questionnaires or research instruments to ensure that they are reliable and provide accurate and consistent data. Conducting test validation is to seek empirical evidence that the measured results of the test do provide accurate, and precise information about the attribute being measured, without being contaminated by irrelevant information (Azwar, 2019). The results of the validity test of the questionnaire of can be seen in the following table:

Table 1. Questionnaire Validation Results

No	Questionnaire	CVI	Category
1	Chatbot Feasibility	1	Very High
2	Students Response	1	Very High

Based on the results above, it can be concluded the questionnaires that were developed got very high categories. Sugiyono (2022), states that an instrument that has high internal validity means that the instrument is built with theories that are relevant to what will be measured and up to date. So it can be concluded that the questionnaires are suitable for research.

Development Stage

The development stage is a crucial phase in the product development cycle, where the conceptual design that has been made in the previous stage becomes a reality. In this process, the conceptual framework, which is still abstract and contained in the design stage, begins to be implemented concretely to form a product that is ready to be applied. Every element that has

been carefully planned and designed in the previous stages is realized into a form that can be tested and implemented. This development stage becomes the bridge that connects conceptual ideas with real products, allowing the development team to measure the performance and functionality of products that previously only existed in the form of planning. Chatbot management systems can be created using web-based applications. With this chatbot management system, chatbots can be created without coding. Therefore, creating chatbots is no longer limited to those who understand programming languages (Hasyim et al., 2021).

The design of this product is formed into a website using the smojoi.ai platform as can be seen in the figure 1 below:

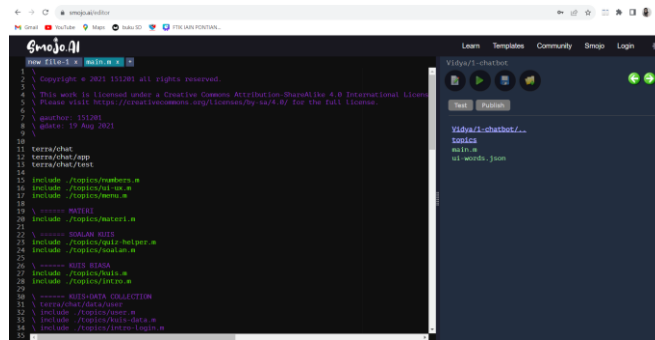


Figure 1. Smojoi.ai Platform

This chatbot can be accessed at the following link: <https://app.smojo.org/vidyasetyaningrum/Vidya>. The display of the chatbot can be seen in the figure 2 and 3 below:

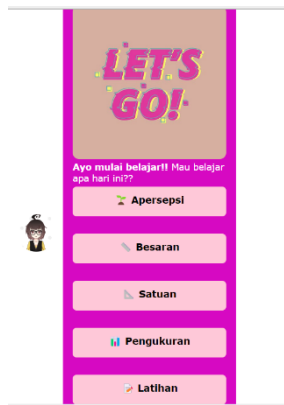


Figure 2. Menu Display



Figure 3. Measurement Display

The chatbot that were developed, then validated by validators. The purpose of validation is to assess the software aspects of the application, the content of the material and the language aspects contained in the chatbots. The validity test was carried out by two validators for each aspects; software, content, and language. The instrument used to collect data in this validation process is a closed questionnaire, while suggestions for improvement are open. The results of the validity test can be seen in the following table:

Table 2. Chatbot Validation Results

No	Aspects	CVI	Category
1	Software	1	Very High
2	Content	1	Very High
3	Language	1	Very High

Based on the results above, it can be concluded that the chatbot that were developed got very high categories for each aspects. So it can be concluded that the chatbot are suitable for use in learning. A digital teaching material with a high validity value means that it provides accurate and reliable information that aligns with the learning objectives and curriculum. It ensures that the content presented is trustworthy and can be used effectively for teaching and learning purposes. This is in accordance with Sundari et al., (2023) who stated that a digital teaching material with a high validity value means that it has been deemed reliable and accurate in terms of its content and effectiveness. A digital teaching material with a high validity value means that it is considered valid and suitable for use in the learning process (Fuadi et al., 2022). Although there are some small notes from validators, such as blurry images, typos and improper use of punctuation, but these notes have been corrected before the chatbot is disseminated to students.

Disseminate Stage

At this stage, the development of teaching materials was carried out through limited distribution to the students in the madrasah ibtidaiyah teacher education study program in IAIN Pontianak. This dissemination aims to get a response to the chatbot teaching materials developed. Ther result can be seen in the table below:

Table 3. Students’ Responses

	Strongly Agree	Agree	Not Agree	Strongly Not Agree
Display	56	123	20	0
Content	64	135	4	2
Utilization	96	93	12	1

Picture 4 showed that students’ give the positive responses about the display, content and utilization. The enthusiastic reception from students towards the newly developed teaching materials serves as a clear testament to their efficacy in fostering comprehension, sustaining interest, and cultivating a positive educational experience. The positive response suggests that the materials resonate well with the students, facilitating a deeper understanding of the subject matter while simultaneously sparking and maintaining their interest. This affirming feedback underscores the significant impact of these teaching materials in creating a favorable and enriching learning environment. This also in accordance to Mohd Lutfi Bin Mohd Khidir et al. (2022), which students have responded positively to AI-powered chatbots as teaching tools.

The test data of both control and experimental groups were then subjected to parametric tests, because the normality test results showed that the data of both classes were normal and homogeneous. As for the results of the t test on both classes are presented as follows:

Table 4. Inferential Statistic

Test	Score
Independent Sample T-Test	0.145
N-Gain	0.3

Based on the data table above the test results of students in the experimental and control classes, it is known that the Sig. value is $0.145 > 0.05$, it is stated that H_0 is rejected and H_a is accepted. So it can be concluded that there is a difference in the average test results of the experimental and control classes. Furthermore, the N-Gain test was conducted to measure the effectiveness of using the chatbot. Based on the results of the calculation of effect size obtained the result of 0.3. This means that the effectiveness of using chatbot is in the medium category. Bano & Ali (2022), states that the integration of ICT-based teaching-learning resources is necessary for effective teaching and learning in higher education. This is because ICT can improve information accessibility, facilitate interaction between lecturers and students, and create an innovative and dynamic learning environment.

Álvarez-Álvarez & Falcon (2023), also find these chatbots effective for learning complex software like AutoCAD. In another study, students expressed a preference for teaching practices that focus on clarity and interaction and relationships (Klos et al., 2021). This indicates that students value clear explanations and opportunities for engagement with teachers and peers (Pradana et al., 2023). Additionally, a pilot study using a chatbot for examining symptoms of depression and anxiety in university students showed promising results in terms of usability and acceptability (Poonawala et al., 2023). The students spent a considerable amount of time interacting with the chatbot and positive feedback was associated with increased engagement. Overall, the use of AI-powered chatbots as teaching materials has shown potential in enhancing student learning and well-being. Therefore, chatbots can be used as an alternative to artificial intelligence-based digital teaching materials in higher education especially in PGMI IAIN Pontianak.

Conclusion

Based on the results of the research that has been presented, it can be concluded that the chatbot of quantity, denomination, and measurement material has high validity. It means that it is considered valid and suitable for use in the learning process. In addition, based on the results of the limited test, the data obtained that students' give the positive responses about the display, content and utilization of the chatbot. Furthermore, the N-Gain test was conducted to measure the effectiveness of using the chatbot. Based on the results of the calculation of effect size obtained the result of 0.3. This means that the effectiveness of using chatbot is in the medium category. Therefore, this chatbot quantity, denomination, and measurement material is suitable for use as teaching material in the college level.

Credit Authorship Contribution Statement

Vidya Setyaningrum: Conceptualization, Resources, Methodology, Coding, Data Analysis, Supervision, Project administration, Writing – original draft, writing review and editing. **Erlina:** Methodology, validation data analysis, Writing – original draft, writing review and editing. **Nuchsara C. Thongsan:** Conceptualization, data analysis, writing review and editing, Proofreader.

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