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Process of building an AI Chatbot Scenario for teaching mathematics to high school students

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Abstract. This article emphasizes the importance of artificial intelligence (AI) in mathematics education and proposes a process for developing an AI Chatbot to support mathematics learning. The purpose is to create an engaging learning environment, provide a valuable tool for teachers and educators, improve the quality of mathematics education, and enhance mathematical skills effectively through artificial intelligence. The article presents the process of building a script for the Chatbot, including planning, design, deployment, testing, and integration into teaching. It analyzes the application of artificial intelligence and machine learning in general and the role of AI Chatbot in education in particular. The design includes a 5-step process for developing an AI Chatbot for teaching mathematics. It starts with defining the script structure, creating script content, integrating the script into AI Chatbot, testing, and conducting trial lessons, and concludes with an evaluation. This process ensures the systematic and efficient development of the Chatbot. The product of this process is an AI Chatbot with the functionality of a virtual teacher capable of supporting the teaching of mathematics and fostering mathematical thinking in students. Using AI Chatbots in mathematics education has the potential to enhance interaction and learning performance. It not only helps students gain a deeper understanding but also stimulates mathematical thinking and learning motivation

Introduction

In the traditional teaching method, conveying mathematical knowledge to students effectively and engagingly poses a challenge for educators. In the current digital age, the fusion of Artificial Intelligence (AI) and education has unveiled significant potential for crafting advanced learning tools. This scientific paper aims to propose a process for constructing a script for an AI Chatbot designed to teach high school-level mathematics. The objective is to demonstrate how AI technology can be leveraged to create a supportive learning tool that stimulates mathematical thinking and enhances students' academic performance in the subject of Mathematics.

The paper delves into the process, starting from planning, script design, deployment, and testing of the Chatbot, up to its integration into daily teaching and learning routines. By mastering this process, educators can harness the power of artificial intelligence to transform the traditionally dry field of Mathematics into a more exciting, engaging, and effective learning experience. Implementing the steps outlined in this script-building process will result in a product – an AI Chatbot or a virtual teacher – that supports the teaching of mathematics, fostering mathematical thinking in students.

Explore how an AI Chatbot can boost student engagement, create a diverse learning environment, and assist educators in their teaching endeavors. We hope that this paper contributes to enhancing the quality of education and maximizing the potential of technology in this field.

Results And Discussion

AI Chatbot is an intelligent conversational system capable of processing human language. It is programmed to interact with users like a real human, with the ability to understand context and words in the dictionary (Wailthare, Gaikwad, Khadse & Dubey, 2018). It comprehends user input and responds meaningfully based on preloaded knowledge (Kumar & Ali, 2020). Yin, Goh, Yang & Xiaobin, (2021) conducted research on the impact of a micro-learning-based chatbot system on students' motivation and academic performance. They used AI Chatbot in combination with microlearning teaching techniques to enhance interaction between students and learning content. It provided timely feedback and self-assessment support. This system allowed students to learn at their own pace, receive prompt feedback, and revisit study materials multiple times to improve learning efficiency. The results of the study showed that students in the chatbot-based learning group had higher intrinsic motivation and achieved academic performance equivalent to the traditional learning group.

Research by Michael Burkhard and colleagues (2022) demonstrated that Chatbots can be used in education as a teaching support tool to help students complete learning tasks, answer questions, and provide useful information. Chatbots can be programmed to interact with students through text or voice chats, assisting them in searching for information, addressing queries, and guiding their learning. Chatbots have aided students in completing learning tasks and provided guidance to student study groups. They have also stimulated metacognitive thinking processes and enhanced student motivation. Many studies have shown that inadequate personal support can lead to poor academic outcomes, while full personal support can improve students' academic performance (Pane, Steiner, Baird, Hamilton & Pane, 2017). The application of microlearning techniques helps reduce student fatigue (Shail, 2019), allowing learners to have more control over the teaching and learning process (Macken – Horarik & Sandiford, 2016). This enables them to determine the pace of their learning during the learning process and can enhance information retention by approximately 20% (Giurgiu, 2017). In many cases, Chatbots have supported students in understanding specific concepts, developing skills, and improving academic results (Nikou & Economides, 2017). Chatbots can serve as instructional aids for organizing questions and answers with feedback for students. Additionally, they can be used to establish communication with families to support the teaching and learning process of students (Garcia-Brustenga, Fuertes-Alpiste & Molas-Castells, 2018).

Scientific Foundation of the AI Chatbot Scripting Process"

Scientific basis of the process of building AI chatbot scenarios. We rely on international publications for the application of AI Chatbot serving teaching for more than 10 years in prestigious journals to perfection the process of building AI chatbot scenarios in teaching. In this paper we use grouping theoretical research methods: Research, analyze, synthesize, systematize and generalize theoretical documents on artificial intelligence technology, AI Chatbot scenarios have been taught in Vietnam and around the world, documents on innovation in teaching methods in general and math curriculum in particular.

According to James Cook University (Australia), pedagogic scenarios (teaching-learning) are primarily created to help teachers achieve their expectations, allowing learners to seek or demonstrate knowledge, skills, attitudes, and learning strategies. Pedagogic scenarios (PS) can take various forms: A collection of instructions, situation introductions, questions, etc., in full or incomplete forms, presented by the teacher to the learner through spoken words, images, sounds, or videos. A text outlining situations with 'blanks' for students to complete on their own. A detailed summary of the roles, role

positions and attitudes, tasks, relationships, and responsibilities of both the teacher and students in the teaching-learning process.

According to professors at Stanford University (www.stanford.edu/group/design_education), after four years of research in implementing the SBL (Scenario-Based Learning) project, they have proposed a model of stages and activities to be undertaken when implementing SBL for teaching topics integrating two content areas, technical design, and business, etc. There are two stages in this process:

+Developing a Scenario-Based Learning Curriculum (SBLC) with four pedagogical modules - Figure 1."

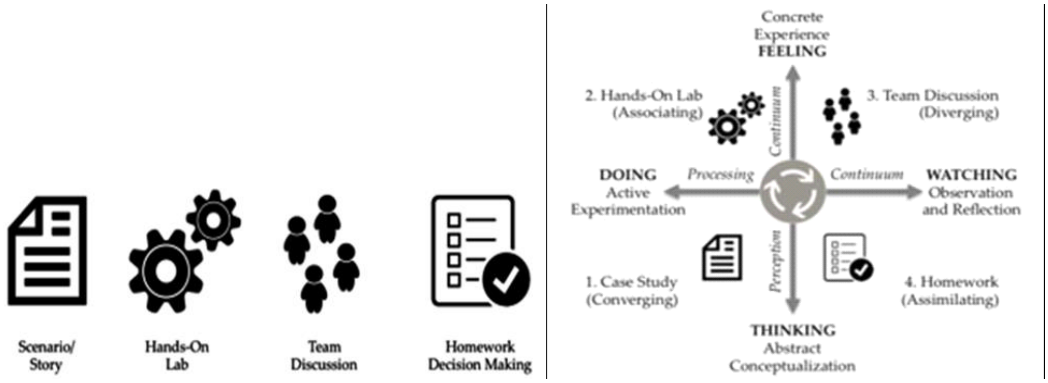

Figure 1. A Scenario-based Learning Model

+ Organizing teaching and learning activities:

This involves rotating through the four pedagogical modules, as depicted in Figure 2, to create and reinforce two continuous learning processes for learners: continuous perception and continuous execution. "Continuous perception" helps learners transition from "thinking" – the process of abstracting concepts – to "feeling" based on experiences. "Continuous execution" encourages students to move from "watching" – the process of observation and reflection – to "doing" – actively engaging with the experiences. This helps learners develop a learning preference with four characteristics: Converging (focusing), Associating (linking related knowledge and skills), Diverging (learning with differentiation), and Assimilating (expressing understanding). In any context, pedagogical scenarios (teaching-learning) remain a crucial and irreplaceable element because of the benefits they offer to learners, teachers, and education managers:

For learners:

They learn how to self-study and self-assess in a humane and scientific way. They develop core humane qualities and high-level competencies. They save time transitioning from academic knowledge and skills to practical application in their future careers and lives.

For teachers and education managers:

A detailed teaching and learning scenario ensures that no content is missed, even down to every word, maintaining balance in teaching and learning quality across different training types and settings. It enables interactive, diverse, and rich teaching and learning, helping learners understand how to study subjects. It achieves a balance in the quality assessment of training from the perspectives of educational institutions, society, and employers. Reduces the pressure and labor for teachers, saving time on pedagogical work, renewing content, teaching methods, etc., according to general trends or regulations. Ensures that the teaching profession's work is aligned with pedagogical objectives. Shortens the training time for adjunct faculty. Encourages teachers to continually improve the quality of their pedagogical work through Total Quality Management (TQM). Facilitates the swift transition of teaching methods while ensuring training quality (Dung, 2020)

According to Giam and Thanh (2022), an AI chatbot scenario is a pedagogical scenario designed to teach using an AI chatbot, transmitting instructional content to students through a virtual teacher, an

AI chatbot. This aims to enhance student's self-learning abilities and improve the quality of teaching. Here, we use an analysis of the math curriculum to create a scenario for an AI chatbot used in math teaching to develop student's mathematical thinking.

Analysis of the Mathematics Curriculum

Mathematics is increasingly applied in daily life. The knowledge and skills in mathematics enable individuals to solve real-world problems systematically and accurately, contributing to societal development. Mathematics in secondary schools plays a role in shaping and developing mathematical qualities and abilities in students, developing essential knowledge, key skills, and providing opportunities for students to experience and apply mathematics in practice. It establishes connections between mathematics and real-life situations and other subjects, especially in implementing STEM education along with other subjects such as science, physics, chemistry, biology, technology, and computer science. Mathematics content often involves logic, abstraction, and generalization. Therefore, to understand and learn mathematics, the secondary school mathematics curriculum needs to strike a balance between "learning" mathematical knowledge and "applying" that knowledge to solve specific problems. Throughout the learning and application of mathematics, students always have the opportunity to use various technological means, modern teaching tools, especially electronic computers and handheld devices, to support the process of representation, exploration, and problem-solving in mathematics (Training, 2018).

The mathematics curriculum helps students achieve the following main objectives:

Develop and enhance mathematical competencies, including the following core elements: mathematical thinking and reasoning skills, mathematical modeling skills, mathematical problem-solving skills, mathematical communication skills, and the ability to use mathematical tools and resources. Contribute to the formation and development of students' essential qualities and general competencies at appropriate levels for the subject and school level, as stipulated in the overall curriculum. Provide students with basic, essential, and fundamental mathematical knowledge and skills. Develop their ability to solve integrated interdisciplinary problems between mathematics and other subjects such as physics, chemistry, biology, geography, computer science, technology, history, art, etc. Create opportunities for students to experience and apply mathematics in practical situations. Provide students with a relatively general understanding of the usefulness of mathematics in various related fields to guide their career orientation. Equipping them with the minimum capacity to self-study related mathematical issues throughout their lives (Training, 2018).

The Process of Developing an AI Chatbot Scenario for Teaching Mathematics

Starting from the importance of mathematics in life, the need for innovation in teaching methods and materials for mathematics, and the benefits of AI Chatbots, the research team realized that integrating a teaching scenario for mathematics into a suitable AI Chatbot would easily achieve teaching objectives and enhance the effectiveness of mathematics education. The scenario development process consists of the following 5 steps:

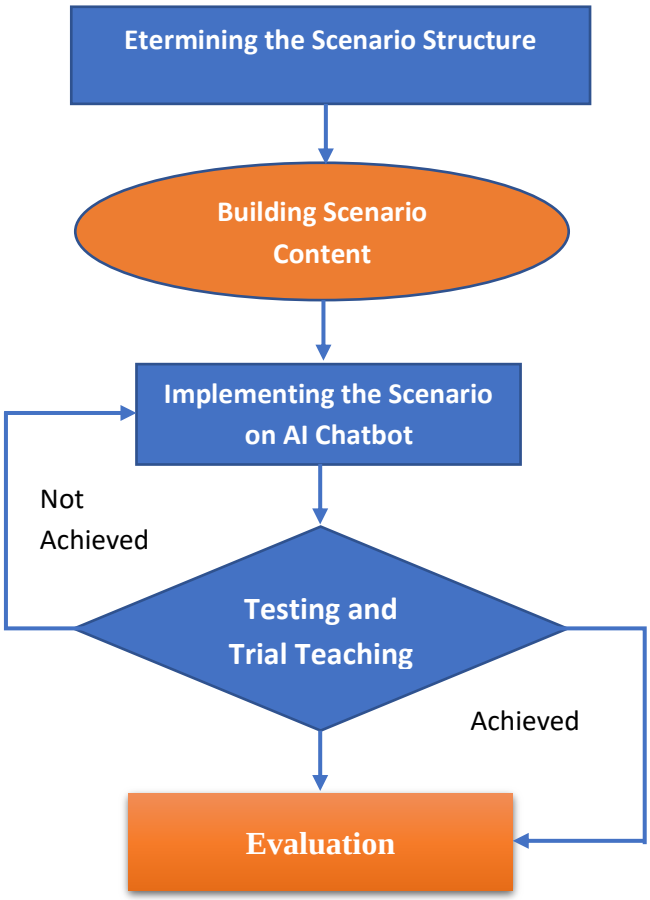

Figure 2. The Process of Developing an AI Chatbot Scenario in Mathematics Education

Step 1: Determine the structure of the scenario

First, the scenario developer must define the teaching goals, prepare and select relevant resources related to lessons in the mathematics curriculum, identify the content that needs to be developed, and find ways to logically connect these contents, making them pedagogically sound. Choose an AI Chatbot platform, such as fpt.ai, for teaching mathematics scenarios.

Step 2: Build scenario content

Building a scenario for a math lesson or an entire math curriculum involves organizing knowledge from basic to advanced levels, including simple to complex formulas, to cater to different levels, abilities, and audiences. Students, whether in class, at home, or anywhere else, can revisit and supplement their mathematical knowledge, whether it's foundational knowledge or advanced concepts. Students can learn from basic to advanced and develop the ability to analyze, infer, synthesize, and apply mathematical knowledge to solve higher-level problems, thus enhancing their mathematical thinking.

Natural Language Processing (NLP) is a core AI feature of the FPT.AI Conversation platform. To enable the bot to understand student and teacher questions, the bot must be trained with specific knowledge related to the content of math lessons. Within FPT.AI, a scenario is a topic that the bot relies on to respond to students. A step is a sub-topic. A scenario includes multiple steps with the same topic. These steps can be linked to each other using nodes. Scenario design involves creating responses based on specific intentions. For intentions without entities in sample sentences, the bot only needs to provide a single response. However, for intentions with entity-containing sample sentences, the bot should provide different responses based on that entity. In such cases, conditions for the variable are used.

Opening section:

Introduction to the overall content, definitions, concepts, theorems, consequences, mathematical formulas, issues to be discussed, and examples of practical applications and problem-solving through

mathematics. To do this, it is necessary to have a clear understanding of the concepts, theorems, mathematical formulas, and theories in the math lesson through steps and suggested content nodes for students to choose from.

Development section:

Knowledge: Construct definitions, concepts, formulas, mathematical symbols used in mathematics, theorems, consequences, and steps to organize logical content. In these steps, mathematical content, modeling, diagramming, application methods, and illustrative examples are provided, relating them to real-life applications through text, images, or videos. *Mathematical problem-solving:* Each step is a practice exercise, solving sample problems, exercises at different cognitive levels (recognition, comprehension, low-level application, high-level application), and solving real-world problems. Nodes will be answer choices, suggestions, or links to the next question, aiming to develop students' mathematical thinking skills. This also enhances the attitude and awareness of each group of students, supports and develops logical, abstract, and creative thinking to find solutions to problems.

Conclusion section:

Develop problem-solving skills for students in mathematics, including understanding and defining basic mathematical concepts, using learned mathematical skills to solve mathematical problems, analyzing mathematical problems to find solutions, synthesizing mathematical ideas from various sources to create new mathematical products, potentially new problem-solving approaches. To design the scenario logically, describe the smaller scenarios and break them down into conversation flows in the form of mind maps.

Implement the scenario on the AI Chatbot

Create a scenario flow for the Chatbot: Divide and digitize each teaching content in a math lesson into smaller topics based on Sample Sentences (The sentences that learners use to ask about issues they need answers to). From there, establish the Intention (the purpose or intent of those questions) of learners in each small topic. At the same time, create Keywords (Important and necessary information in the sentence, helping the bot understand the issue that learners are talking about to provide a suitable answer). Develop Entity types (Representing the meaning of the Keywords above) in Sample Sentences, a set of Sample Sentences that learners will ask about each issue for the bot to teach.

Sample sentences are crucial for chatbots. Therefore, teachers should add as many sample sentences as possible. The diversity of sample sentences will help the chatbot understand various questions from learners. Determine the most relevant intentions based on user interests, experience, questions, and conversation history. Then, add as many diverse sample sentences as possible for those intentions. When implementing each content of the teaching scenario on the AI Chatbot, it must strictly follow the sequence of the scenario structure and the scenario developed in steps 1 and 2. Simultaneously, supplement background knowledge such as definitions, theorems, consequences, formulas, mathematical symbols, etc., for each content in the teaching scenario on the AI Chatbot (estimated and constructed by the teacher). When students need it, they will get an immediate response. This is crucial and a very useful feature of the AI Chatbot.

Testing and trial teaching

Test the bot's intelligence by asking it random questions about formulas, definitions, theorems, and solving a problem to assess the bot's accuracy in answering. Check for errors and address them from the digitization step to the end of putting the teaching scenario on the bot until the accuracy reaches 100%. Then proceed with trial teaching. It is essential to test multiple times before formal teaching to detect errors, make adjustments, and accumulate and add new knowledge to the AI Chatbot to make it smarter.

Step 5: Evaluation

Evaluate the quality and effectiveness of teaching mathematics using the AI Chatbot by achieving the teaching objectives for mathematics. Improve the scenario, make adjustments, and enhance the quality and effectiveness of teaching in developing students' mathematical thinking. With this AI Chatbot scenario development for teaching, it can be applied not only to mathematics but also to other subjects according to the educational institution's goals. Applying the steps in this scenario development process will create a product that is an AI Chatbot or a virtual teacher to support the mathematics teaching process aimed at developing students' mathematical thinking. With this virtual teacher, it will free up resources and time for teachers during the teaching process, where teachers act as guides.

Conclusion

This paper has presented in detail the process of building a scenario for an AI Chatbot applied to high school mathematics. The aim of this process is to create an advanced learning tool with the assistance of an AI Chatbot, providing efficiency in the learning process of mathematics. The following are the key points of the process and research outcomes: The paper discussed the role of AI Chatbots in supporting learning and providing useful information for students. AI Chatbots not only help students complete learning tasks effectively but also create an engaging learning environment. The paper also analyzed the scientific foundations of artificial intelligence and machine learning to understand how AI Chatbots work and how to apply these principles to build a robust and intelligent Chatbot. The paper conducted an analysis of the mathematics curriculum to determine the important aspects needed in the AI Chatbot scenario. This helps ensure that the AI Chatbot effectively supports students in accessing knowledge and solving exercises, as well as developing mathematical thinking. The process of building an AI Chatbot for teaching mathematics consists of 5 steps. Starting from determining the script structure, creating the script content, integrating the script into the AI Chatbot, testing and conducting trials, and finally, evaluation. This process ensures that the Chatbot is developed systematically and effectively. The product of this process is an AI Chatbot or a virtual teacher that supports the teaching of mathematics to develop students' mathematical thinking. The research results show that using AI Chatbots in teaching mathematics has great potential to enhance student interaction and learning performance. Chatbots not only help students gain a deeper understanding of concepts but also promote the development of mathematical thinking and learning motivation. We hope that this process will be a useful tool for teachers and educators in harnessing the potential of artificial intelligence to improve the quality of education in mathematics and support students in developing mathematical skills effectively. We would like to thank all those who participated in this research process for their interest and contributions. We hope that this paper will contribute to the development of education and the application of artificial intelligence in this field.

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