# Teaching Mathematics with the Assistance of an AI Chatbot to Enhance Mathematical Thinking Skills for High School Students

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**ABSTRACT:** The paper introduces the concepts of thinking and mathematical thinking, emphasizing the significance of mathematical thinking in problem-solving and the development of mathematical skills. It elaborates on the process of mathematization, highlighting its role in fostering problem-solving abilities. Furthermore, the article discusses Teaching with the assistance of an AI Chatbot, the objectives of high school mathematics programs, and presents the Teaching Process in Mathematics with the assistance of an AI Chatbot to develop mathematical thinking skills for students. This process includes steps such as defining goals, logging into the AI Chatbot, identifying learning tasks, problem-solving, learning, application and experience, assessment, conclusion, analysis, inference, and mathematical problem-solving. The integration of the AI Chatbot is emphasized, creating a dynamic learning environment that supports students. The AI Chatbot not only provides knowledge but also stimulates curiosity and creativity, helping students understand and apply mathematics to real-world scenarios. The paper provides scientific insights into the application of AI technology in mathematics education, supporting the learning process and developing the mathematical thinking of high school students.

**KEYWORDS:** AI Chatbot, development of mathematical thinking, high school students, Mathematical thinking, teaching mathematics, teaching process.

## INTRODUCTION

In the current era of digital transformation, the keywords "Thinking" and "Mathematical Thinking" have garnered special attention from educators, seeking to maximize the development of cognitive abilities in learners. Mathematical thinking is not only about calculation or solving equations and problems but also involves using mathematical skills to address daily life issues.

Internationally, the term "mathematical thinking" first appeared in Dewey's research in 1910. Humans think about various situations, including those they have not encountered, experienced, or heard of before. Thinking about a specific problem requires recognizing it in some way and proceeding through steps by determining what is about to happen.

Schoenfeld (1992) and Freudenthal (1973) introduced the term "mathematization" to assess the process of transforming general thinking into mathematical thinking, asserting that this process starts from real experiences and leads to mathematics. Mathematization is considered a crucial element in mathematical thinking, helping us solve real-world problems.

From the concept of "mathematical thinking," the paper focuses on introducing and evaluating a particular teaching process in mathematics, using the assistance of an AI Chatbot, with the primary goal of developing mathematical thinking skills for high school students. In an era where technology plays a crucial role in education, integrating artificial intelligence into the teaching process becomes increasingly essential. This paper not only introduces a novel method but also discusses the benefits and potential that an AI Chatbot brings in disseminating mathematical knowledge and enhancing students' mathematical thinking abilities.

## 1. Thinking and Mathematical Thinking

### 1.1. Thinking

According to Phan Dung (2013), thinking is a positive reflection of reality, associated with solving this problem or another problem, and is the highest product of a specifically organized material - the human brain. The result of thinking is thoughts that solve problems.

According to Tran Khanh Duc (2012), thinking is the mental, intellectual, and conscious activities of humans with the material source being the brain. Thinking is not only the process of perception, and reflection (direct or indirect) but also the process of action

(action thinking or transformation) to solve practical problems and transform, adapt to the objective reality (nature, society, and human itself).

According to Edgar Morin (2009), thinking is the highest method of organizing activities of the mind, which through language, establishes its perception of reality and its worldview.

In summary, thinking is an intellectual activity affecting the brain, reflecting the conscious perception of the objective phenomenon, to solve problems, and relationships in the daily life of human society.

### *1.2. Mathematical Thinking*

Henderson, Hichtner (2002), and other researchers have defined mathematical thinking as a creative process to create mathematical knowledge by linking existing knowledge with new knowledge to solve mathematical problems. According to Liu (2003), mathematical thinking is a combination of processes such as prediction, induction, interpretation, description, generalization, sampling, formal and informal reasoning, verification, and similar complex processes based on definitions and explanations that have been made about mathematical thinking. According to Mason, Burton & Stacey (2010), Mathematical thinking is a dynamic process that helps us understand complex structures more easily by combining our ideas. Schoenfeld (2014) defined "mathematical thinking" as the process of searching, problem-solving, reasoning, analyzing, and interpreting information logically and accurately.

Jacobs, Lamb, and Philipp (2010) described the observation activities of mathematical thinking of students observed by teachers, including 3 steps:

- Observe students' problem-solving approaches: teachers have a deep understanding of mathematical thinking to recognize this thinking process of students to suggest detailed ways to solve mathematical problems for students through rules and break down information in complex situations.
- Explain students' mathematical understanding: Through the process of solving students' problems, teachers explain specific issues relevant to details in the problem-solving approach and the principles of students' mathematical understanding as well as the development of students' mathematical thinking.
- Propose teaching approaches: Through observing and explaining students' mathematical understanding find appropriate teaching approaches to develop mathematical thinking for students.

According to us: *Mathematical thinking is a complex cognitive process, including many different thinking activities such as searching, reasoning, analyzing, and interpreting information logically and accurately, helping students use mathematical knowledge and skills to solve problems effectively, including problems in daily life.*

### 2. Teaching with the Assistance of AI Chatbot

According to Giam and colleagues (2022), an AI Chatbot is an intelligent chat system capable of processing human language. As stated by Baskara (2023), Chatbots can be utilized to provide support for students in their learning by answering questions, offering information on study topics, and providing feedback on students' learning outcomes. The use of Chatbots in teaching enhances flexibility and diversity in learning, allowing students to learn at their own pace and according to their individual learning styles, thereby increasing interest and motivation for learning and contributing to improved academic performance. Research by Suhni Abbasi and colleagues (2019) demonstrates that Chatbots can be used in education as an effective tool to provide efficient answers and meet the needs of students. Chatbots can also help students enhance their class participation and improve their learning skills. According to Giam and colleagues (2023), a common application of AI Chatbots is the creation of intelligent tutoring systems, providing personalized learning environments for students by analyzing their feedback and how they experience learning content. Therefore, AI Chatbots can be used to teach students by delivering a lesson through a series of messages, images, and videos, supporting students in understanding basic to advanced mathematical concepts. AI Chatbots help provide instant answers to students' queries 24/7 in a fully intelligent and automated manner. This can assist students in solving their learning problems quickly, effectively, and with personalized support. Moreover, unlike humans, Chatbots have infinite patience, are impartial, and have no reservations about answering the same question multiple times. The use of AI Chatbots in teaching through instructional scenarios developed by teachers and educators enables the development of self-learning capabilities for students by combining machine learning methods and artificial intelligence to customize learning content, cater to the needs and learning abilities of each student, provide automatic support and instant feedback, thereby creating an individualized and effective learning environment for each student.

### 3. Objectives of the High School Mathematics Curriculum

The High School Mathematics curriculum aims to help students achieve the following main objectives (Vietnam Ministry of Education and Training, 2018):

a) Contribute to the formation and development of mathematical competence with the following requirements: state and answer questions in reasoning, and problem-solving; use reasoning, induction, and deduction methods to understand different approaches to problem-solving; establish mathematical models to describe situations, thereby proposing solutions to mathematical problems posed in established models; perform and present solutions to problems and evaluate implemented solutions, reflect on the value of the solutions, and generalize for similar issues; use tools and mathematical learning methods in exploration and problem-solving in mathematics.

b) Possess basic and essential mathematical knowledge and skills in:

– Algebra and Some Analytical Factors: Calculating and using computational tools; using the language and symbols of algebra; transforming algebraic expressions and mastering algebraic structures (trigonometry, exponentials, logarithms), equations, systems of equations, and inequalities; recognizing basic elementary functions (exponential, trigonometric, logarithmic); studying functions and graphing function graphs using derivative tools; using function language, function graphs to describe and analyze some processes and phenomena in the real world; using integration to calculate the area of flat shapes and the volume of objects in space.

– Geometry and Measurement: Providing knowledge and skills (at the level of logical inference) about geometric relationships and some familiar flat and solid shapes; algebraic methods (vectors, coordinates) in geometry; developing spatial imagination; solving simple practical problems related to geometry and measurement.

– Statistics and Probability: Enhancing the ability to collect, classify, represent, analyze, and process statistical data; using statistical analysis tools through characteristic numbers measuring central tendency and dispersion for non-grouped and grouped samples; using statistical laws in practice; recognizing basic random models, basic concepts of probability, and the significance of probability in practice.

c) Contribute to helping students have relatively general knowledge about professions related to Mathematics and its value; serve as a foundation for career orientation after high school; have sufficient minimum capacity to self-study issues related to mathematics throughout life.

### 4. The process of Teaching Mathematics with the Support of AI Chatbot Process

The process of teaching mathematics with the support of an AI Chatbot to develop mathematical thinking for high school students is conducted through the following steps:
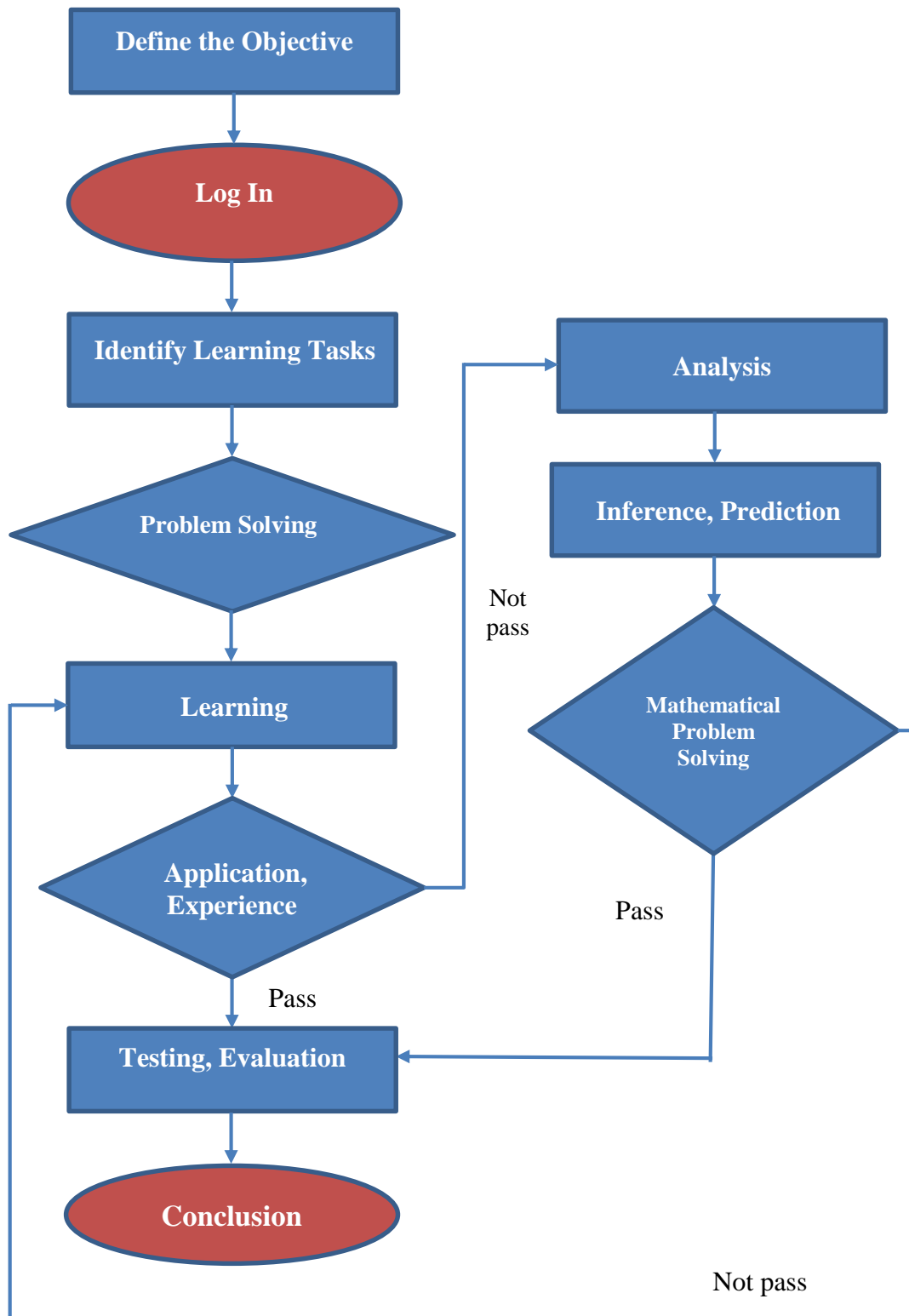
**Figure 1.** The process of teaching mathematics with the support of AI Chatbot to develop mathematical thinking for high school students

*Step 1. Define the Objective:*

Define the desired outcomes after completing a lesson, topic, or chapter. Teaching objectives need to be clear, specific, measurable, achievable, related to the development of mathematical thinking, and aligned with the requirements of the high school mathematics curriculum.

*Step 2. Log In:*

Log in to the AI Chatbot that has been scripted for the development of mathematical thinking in high school mathematics teaching. The Chatbot is integrated into social media platforms or websites.

*Step 3. Identify Learning Tasks:*

Identify learning tasks that students need to complete to achieve the teaching objectives according to the SMART principle: specific, measurable, achievable, results-oriented, and time-bound. Designing learning activities to help students develop mathematical thinking skills. Students need to allocate time and schedule their studies to ensure the completion of learning tasks in the subsequent steps.

*Step 4. Problem Solving:*

In this step, the teacher constructs a script for the AI Chatbot with content related to the following activities:

Warm-up Activity: The teacher creates a script for the AI Chatbot to generate interest among students and stimulate their mathematical thinking.

Knowledge Building Activity: The AI Chatbot provides lesson content, answers students' questions, helps students understand concepts, theorems, definitions, problem-solving steps, and mathematical issues.

Practice Activity: The AI Chatbot provides various exercises suitable for students' proficiency levels, helping them reinforce knowledge and develop problem-solving skills.

Application Activity: The AI Chatbot presents real-world scenarios, assisting students in applying mathematical knowledge to solve problems in life.

Assessment and Evaluation: The AI Chatbot provides questions to assess and evaluate students' understanding of the lesson and their mathematical thinking.

*Step 5. Learning:*

Students engage in learning activities with the guidance and support of the AI Chatbot through the following learning activities:

Warm-up Activity: Students participate in warm-up activities with intriguing puzzles or real-life problems to generate interest and stimulate their mathematical thinking.

Knowledge Building Activity: Students engage in learning lesson content with the AI Chatbot, ask questions, research, and link related knowledge to the lesson content.

Practice Activity: The AI Chatbot offers exercises related to the lesson content, suitable for students' proficiency levels, helping them memorize and reinforce knowledge, and develop problem-solving skills.

*Step 6. Application, Experience:*

The AI Chatbot provides problems for applying learned knowledge and real-life situations, helping students apply mathematical knowledge to solve problems in life. Students participate in the learning process, research, and apply mathematics, gaining new knowledge, skills, and experiences to develop their mathematical thinking. If students do not meet the requirements in this step, they proceed to step 9 for analysis and subsequent steps to complete learning tasks and achieve learning objectives.

*Step 7. Testing, Evaluation:*

The AI Chatbot provides questions to test and evaluate students' understanding of the lesson and their mathematical thinking. If successful, the learning process proceeds to the conclusion.

*Step 8. Conclusion:*

The learning process and students' mathematical thinking activities conclude. The AI Chatbot reminds students to review previous lessons and explore new lessons on their own.

### Step 9. Analysis:

Analysis involves breaking down a mathematical problem, situation, or scenario into smaller components to understand the relationships between them. Analysis is a crucial step in the mathematical problem-solving process, helping students understand the problem to be solved and find appropriate solutions through thinking, reasoning, and completing learning tasks. It helps students understand mathematical concepts, theorems, and problem-solving methods, thereby developing logical thinking and inference.

### Step 10. Inference, Prediction:

This process involves thinking, and predicting based on the evidence, and information already available in the mathematical problem or lesson. It helps to find a result, and discover relationships between content to find logical and accurate directions for further content development. Logical thinking and prediction help students develop creative thinking, find new, unique solutions to mathematical problems, and accumulate mathematical knowledge and skills.

### Step 11. Mathematical Problem Solving:

Mathematical problem-solving is the process of finding ways to solve a mathematical problem. Solving a mathematical problem is a complex process that requires many skills and knowledge of mathematics. To solve a mathematical problem, students need to use logical thinking and inference skills to analyze the mathematical problem, find relationships between knowledge content, and connect information to step-by-step development of information to carry out learning tasks to solve the problem. It leads to the appropriate conclusion. If students pass the problem-solving step, they move on to the Testing and Evaluation step (Step 7), and if successful, they proceed to the Conclusion step (Step 8).

## 5. CONCLUSION

In the context of digital transformation and the need to enhance mathematical thinking abilities for high school students, research on the teaching process of mathematics with the support of an AI Chatbot has brought positive results and prospects for education. The article focused on developing mathematical thinking through a structured and organized learning process, using the AI Chatbot as an essential supporting tool.

The article discussed the concept of mathematical thinking and the use of AI Chatbots in teaching support. Furthermore, the article presented a specific teaching process, starting from defining learning objectives to applying and solving mathematical problems. The integration of AI Chatbots into the teaching process has created a dynamic, exploratory learning environment, supporting students in developing their mathematical thinking. AI Chatbots not only provide knowledge but also stimulate curiosity and creativity, helping students learn more effectively.

Additionally, the article also pointed out that integrating technology into education requires careful consideration and proper integration to create a positive and multidimensional learning experience. Evaluation and monitoring of the results of the teaching process are essential to ensure the effectiveness and quality of education.

In summary, the article addressed an innovative method of teaching mathematics, using AI technology to support and encourage the mathematical thinking of high school students.

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