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Supporting Math Instruction with AI: A Teacher-Oriented Chatbot Approach

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Personal Motivation

My interest in this research stems from a long-standing passion for education. Since secondary school in China, I have enjoyed helping classmates understand math prob- lems, which sparked my enthusiasm for teaching. During my undergraduate studies in Mathematics and Applied Mathematics, I worked as a private tutor for high school stu- dents and later interned at a local education institution. These experiences deepened my understanding of the challenges teachers face in preparing effective lessons.

High school mathematics teachers in China often deal with large class sizes and stu- dents of varying abilities. Many students struggle silently with foundational concepts, making it hard for teachers to detect issues in time. While many AI tools focus on sup- porting students, few are designed to help teachers during lesson planning, especially in anticipating student difficulties or framing questions effectively.

This project aims to address that gap. I aim to propose an AI chatbot that simulates diverse student responses and helps teachers explore different teaching strategies. My background in mathematical modeling provides the technical foundation, while my teaching experience offers practical insight. Through this project, I hope to improve how teachers prepare for class and ultimately support more personalized, responsive instruction in Chinese high schools.

1 Introduction

Artificial intelligence (AI) is increasingly integrated into educational environments, re- shaping how students and teachers interact with learning content. AI refers to machines that demonstrate human-like intelligence, including learning, adaptability, and decision- making [1]. Tools like Duolingo, Grammarly, and AI-based learning management systems (e.g., Absorb LMS, Docebo) are widely used to enhance personalization, automate tasks, and support both teaching and learning [2, 1]. These technologies expand learning beyond traditional classrooms and promote more flexible educational models [3, 4].

However, most existing research and implementations of AI in education focus on students. Studies show that AI chatbots help students learn at their own pace, reduce pressure, increase motivation, and improve academic outcomes in smart classrooms [5, 6].

While some work has been done to explore AI's use in teacher training [7], or teachers' perspectives on student-AI collaboration [8], there remains a lack of focus on AI tools that support in-service teachers during lesson preparation. This gap is pressing, particularly in the context of Chinese high school mathematics, where students' learning values vary across culture, memorization, technology, and understanding [9].

To address this, I propose an AI chatbot system to support mathematics teachers in preparing instruction. This tool simulates realistic student-teacher dialogues, combines standardized question templates with adaptive logic informed by student profiles, and helps teachers design more effective and responsive lessons.

2 Literature Review

Overview

Information technologies, especially artificial intelligence (AI), are transforming modern education [10]. Social networks, wikis, blogs, YouTube, interactive websites, and mobile communication tools have increasingly replaced face-to-face meetings as platforms for learning [11]. For example, Duolingo, a language learning platform, uses advanced AI systems to enhance the learning experience [2]. AI-powered learning management sys- tems (LMS), such as Absorb LMS and Docebo, offer various AI features that support both teaching and learning. These include intelligent content creation, automation of administrative tasks, and personalised learning [12]. Moreover, Grammarly uses AI to help correct and improve writing.

AI for Teacher Development

Some researchers imply that teachers will be concerned about the AI tool at the beginning if they have no idea about how AI works [13]. However, with the increasing connection with AI in daily life, teacher professional development in the age of AI requires a well-rounded approach that includes specific skills and competencies, effective strategies, collaborative learning, and a strong commitment to continuous improvement and adaptation [14]. Instead of focusing only on the technical adoption of AI tools or how teachers help design them, it is important to look at how these tools can be meaningfully

integrated into teachers' daily practice. This helps them build knowledge-based reasoning skills, understand key teaching concepts, and develop new ways of thinking about their practice [15]. Design AI-based educational software to help improve teachers' skills, and create training programs using artificial intelligence for everyone working in the education sector will serve the professional development of teachers [16]. However, few studies have explored how AI can simulate real teaching interactions to help teachers prepare questions and teaching strategies before entering the classroom.

Theories on Student Differentiation

Differential differentiation occurs when curriculum changes are based on students' preferred learning styles rather than the teacher's judgment [17]. Differentiated instruction should be a standard teaching approach. It offers students meaningful and relevant learning choices, engaging and motivating learners of all abilities and learning styles [18]. Meanwhile, students exhibit different characteristics, which result in learning differences. Various factors, such as cognitive abilities, learning styles, motivation, interests, and cultural background, influence individual differences in learning [19]. Additionally, MBTI can be a factor for modeling to support student-centered learning and help teachers better understand and develop each student's potential [20]. However, adjusting the MBTI to the students remains a challenge.

Students may progress through the material at different speeds depending on their individual learning paces [21]. Personalized education can better support the development of individual innovation potential, making it more suitable for the needs of a modern, innovation-driven society [22]. Some scholars have developed an approach for teachers to choose personalization settings and combine them flexibly to create different strategies based on the specific needs of each course [23].

Gaps in the Current Literature and How This Project Addresses Them

Most current research on AI in education focuses on student-facing applications, such as personalised learning platforms or automated feedback tools. However, limited attention has been given to how AI can support teachers during lesson preparation. Studies on

teacher development emphasise skills and mindsets, but rarely explore tools that simulate real classroom interactions.

This project plan to fill the gap by designing an AI chatbot to help teachers plan effective questions and anticipate student misunderstandings. It integrates standardised questioning strategies with personalised student models based on learning profiles and traits. Doing so bridges the gap between standardised pedagogy and differentiated instruction, offering teachers a more adaptive and efficient way to prepare for diverse classroom scenarios.

3 Research Objectives and Questions

Research Objectives

This project aims to design and implement an AI chatbot system that assists high school mathematics teachers by:

- Simulating diverse classroom teaching scenarios;
- Enhancing teacher understanding of student cognitive and emotional responses;
- Developing both standardized and personalized questioning strategies;
- Improving the naturalness and efficiency of teacherr—student interactions.

Research Questions

1. How can AI support teachers in understanding student difficulties at the early stages of learning in each module?
2. How can student types (based on MBTI profiles, performance levels, etc.) inform tailored questioning strategies?
3. What framework allows AI to support standardized teaching patterns and individualized student needs simultaneously?

4 Methodology

To answer these questions, we propose a four-step methodology:

4.1 Needs Assessment and Corpus Collection (Addresses RQ1)

To understand how AI can assist teachers in identifying student difficulties early (RQ1), we will conduct a comprehensive needs assessment involving surveys and in-depth interviews with high school mathematics teachers across diverse regions in China. This approach ensures a broad and representative sample, capturing the varied experiences and challenges faced by teachers with different levels of experience and from different educational contexts. Using thematic analysis, we will systematically extract common challenges and misconceptions students face at the beginning of new modules. This process will also involve collecting real classroom dialogues and teacher notes, forming the basis for the chatbot training data. Additionally, we will employ advanced natural language processing (NLP) techniques to analyze the collected data, identifying key patterns and indicators of student difficulties. This step will lay the foundation for developing an AI-driven early warning system that can flag potential issues in real-time, enabling teachers to intervene promptly.

4.2 Student Modeling and Question Template Design (Addresses RQ2)

To explore how student typologies can inform differentiated questioning (RQ2), we will classify students based on a combination of MBTI types, academic performance, learning styles, and other relevant factors. Educational psychology literature will guide the construction of questioning templates adapted to various student categories. Templates will specify tone, structure, difficulty level, and optimal timing for each question type, helping simulate tailored teaching strategies.

4.3 AI Chatbot Design and Development (Addresses RQ3)

To design a system that balances standardization and personalization in teaching (RQ3), we will develop an AI chatbot that supports teachers in lesson preparation. The system will integrate a dual-layer framework: (1) a set of standardized questioning structures based on common patterns in effective teaching, and (2) adaptive logic that modifies these structures according to student types. The chatbot will simulate responses, suggest questions, and help teachers plan dialogue strategies before class.

4.4 Training and Evaluation(Addresses RQ1-RQ3)

The AI chatbot will be trained on teacher-student interaction data—either real classroom dialogue or simulated exchanges based on the collected corpus. Evaluation will be conducted from two complementary perspectives: **Quantitative Evaluation:**

- Reduction in teachers' lesson preparation time;
- Improvement in student performance (e.g., test scores or concept mastery rate) after teacher use of the chatbot;
- Accuracy of chatbot-generated student-type classification and suggested questions.

Qualitative Evaluation:

- Teacher feedback gathered through structured surveys and interviews regarding the usability, relevance, and helpfulness of the chatbot;
- Observations of classroom practices to assess how the tool influences teachers' questioning strategies and classroom engagement;

5 Expected Outcomes

- A practical AI tool that enhances lesson planning and student communication for high school math teachers;
- A curated set of standardized questioning templates applicable to various teaching scenarios;
- A framework for integrating personalization and standardization in AI-assisted teaching;
- Contributions to interdisciplinary research at the intersection of artificial intelligence, educational psychology, and pedagogy.

6 Timeline

- **Year 1:** Literature review, teacher interviews, student-type modeling;

- **Year 2:** Dialogue template development, chatbot system prototype;
- **Year 3:** Model training and refinement, pilot testing;
- **Year 4:** Large-scale evaluation, final analysis, thesis writing and defense.

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