



THE ROLE OF ARTIFICIAL INTELLIGENCE IN TEACHING DIFFERENTIAL EQUATIONS TO UNDERGRADUATE STUDENTS

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Abstract:

Artificial Intelligence (AI) is revolutionizing higher education by making teaching and learning more engaging, customized, and effective. In mathematics education, particularly in Differential Equations, AI enables undergraduate students understand abstract concepts through visualization, step-by-step explanations, adaptive learning, and instant feedback. AI-based tools such as ChatGPT, Wolfram Alpha, and Microsoft Math Solver strengthen students' problem-solving skills and conceptual knowledge. This paper examines the significance of AI in teaching Differential Equations to UG students, highlighting its advantages, limitations and practical strategies for successful integration into undergraduate classrooms.

Keywords: Artificial Intelligence, Differential Equations, Wolfram Alpha, Microsoft Math,Solver, ChatGPT, Adaptive Learning.

1. Introduction:

Artificial Intelligence (AI) has become an important innovation in contemporary education. AI-powered learning tools assist learners by offering customized learning, immediate feedback, and engaging learning experiences. Mathematics is often regarded as a challenging discipline analytical reasoning and conceptual thinking. Differential Equations is one of the most complex subjects for undergraduate students due to its theoretical nature and numerous practical of applications.

AI can enhance the teaching of Differential Equations by enabling students to visualize solutions, solve problems in systematic manner and learn independently. These technologies boost students' confidence and improve their academic achievement.

2. Objectives of the Study:

- To analyze the role of AI in teaching Differential Equations.
- To recognize AI tools beneficial for undergraduate mathematics education.
- To investigate the advantages of AI in enhancing conceptual understanding.
- To evaluate the challenges of AI implementation in mathematics teaching.
- To suggest recommendations for successful AI-based instruction.

3. Hypothesis:

Alternative Hypothesis (H_1) There is a significant positive effect of using Artificial Intelligence tools on the teaching and learning of Differential Equations among undergraduate students.

4. Review of Literature:

Artificial Intelligence in Mathematics Education: Artificial Intelligence refers to computer systems capable of performing tasks that normally require human intelligence, such as learning, reasoning, problem-solving, and decision-making.



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In mathematics education, AI is used for:

- Personalized learning
- Automated assessment
- Intelligent tutoring
- Interactive visualization
- Instant feedback
- Adaptive practice exercises

4. AI Tools for Teaching Differential Equations:

4.1 ChatGPT:

Explains Concepts Clearly – Provides simple, clear, and detailed explanations of differential equation concepts according to students' learning levels.

Solves Problems Step-by-Step – Demonstrates complete solutions with logical reasoning, helping students understand each stage of the solution process.

Provides Instant Doubt Clarification – Answers students' questions immediately, enabling self-paced learning and improving conceptual understanding.

Generates Practice Questions – Creates exercises, quizzes, and model problems with solutions to strengthen problem-solving skills.

Supports Personalized Learning – Adapts explanations, examples, and practice materials based on individual students' abilities and learning needs.

Enhances Real-World Understanding – Explains practical applications of differential equations in engineering, physics, biology, economics, and other fields, making learning more meaningful.

4.2 Wolfram Alpha:

Wolfram Alpha is an Artificial Intelligence-powered computational tool that supports the teaching and learning of Differential Equations at the undergraduate level. It offers systematic solutions for various types of differential equations, helping students grasp the solution procedure effectively. The tool also displays graphical representations of solutions, making complex concepts easier to interpret and analyze. Furthermore, it enables students to evaluate their manual calculations, recognize mistakes, and develop their problem-solving abilities. By promoting conceptual understanding, graphical visualization, and autonomous learning, Wolfram Alpha functions as a valuable educational resource for Differential Equations.

4.3 Microsoft Math Solver:

Microsoft Math Solver is an Artificial Intelligence-based learning tool that facilitates the teaching and learning of Differential Equations at the undergraduate level. It offers detailed step-by-step solutions that help students comprehend the methods used to solve differential equations. The tool enables students to input equations by typing or scanning them with a camera, making it convenient for use in both classroom and independent learning environments. It also helps students check their solutions, recognize mistakes, and develop their problem-solving abilities. By providing simple explanations and immediate feedback, Microsoft Math Solver promotes conceptual understanding and supports self-directed learning in Differential Equations.



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5. Review of Past Research:

Anjie Manto, Mitchie Anne Visitacion et.al in their research paper titled, “AI integration in mathematics education: A systematic review of implementation challenges and pedagogical implications (2017-2025)”, published in Social Sciences & Humanities Open Volume 14, December 2026, 103147, analysed as Drawing on 54 studies published between 2017 and 2025, this review consolidates current evidence on the integration of artificial intelligence into mathematics education, capturing both its pedagogical potential and its inherent complexities. The findings indicate that while AI can support conceptual understanding, personalization, and diverse forms of mathematical engagement, its use is accompanied by substantive concerns, including learner overreliance, challenges to assessment validity, limited support for deep reasoning, and persistent issues of equity and access.

Dr. M. Padma Associate professor of mathematics G. Narayanamma Institute of Technology and Science Hyderabad, Telangana in her research paper titled, “Artificial intelligence in teaching mathematics” published in Recent Trends on Humanities and Basic Sciences (ISBN: 978-93-5779-832-7) pointed out as The goal of today's higher education is to significantly raised up standard of Institution artificial intelligence advancement in technology give instructors and students the chance to solve problems and enhance the teaching and learning process by providing a thorough review of artificial intelligence in mathematics teaching and learning for students at all levels of education this paper host to contribute to the to the discourse these days one of the discipline with the greatest educational impact in mathematics which have several applications in social interaction.

Gwo-Jen Hwang and Yun-Fang Tu in their research paper titled, “Roles and Research Trends of Artificial Intelligence in Mathematics Education”: A Bibliometric Mapping Analysis and Systematic Review” Published 10 March 2021 explained as Author(s) (Year) conducted a systematic review and bibliometric analysis on the role of Artificial Intelligence in Mathematics Education. The study reported that AI helps diagnose students' learning difficulties, provides personalized learning support, and improves learning outcomes in mathematics. The authors also identified current research trends and suggested future research directions in AI-based mathematics education. However, the study did not specifically focus on the teaching of Differential Equations.

6. Applications of AI in Teaching Differential Equations:

Step-by-step problem solving: ChatGPT, Wolfram Alpha, and Microsoft Math Solver provide a comprehensive AI-supported environment for solving differential equations through step-by-step guidance. Students first enter the differential equation into any of these tools, which automatically identify the appropriate solution method and generate a detailed solution by explaining each mathematical step. ChatGPT offers conceptual explanations and personalized doubt clarification, Wolfram Alpha provides accurate computational procedures and graphical visualization, while Microsoft Math Solver delivers structured step-by-step solutions with instant feedback. By combining these AI tools, students can understand solution methods, verify answers, correct mistakes, and practice additional problems, thereby improving conceptual understanding, computational accuracy, problem-solving skills, and independent learning in differential equations.

Interactive simulations: Interactive simulations play a significant role in improving the teaching and learning of differential equations by enabling students to explore mathematical concepts dynamically. ChatGPT, Wolfram Alpha, and Microsoft Math Solver can be effectively integrated to create an interactive learning environment. ChatGPT acts as an intelligent tutor by explaining differential equation concepts in simple language, guiding students through step-by-step solution methods, generating practice problems, answering questions instantly, and encouraging conceptual understanding through interactive dialogue. Wolfram Alpha complements this process by providing accurate symbolic and numerical solutions, plotting direction fields, slope fields, phase portraits, and solution curves, allowing students to visualize how solutions change with different initial conditions and parameter values. Microsoft Math Solver further enhances learning by offering step-by-step solutions, graphical representations, and alternative solution methods, enabling students to verify their work and understand each stage of the solution process. Together, these AI-powered tools create an interactive simulation



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environment where students can solve problems, visualize mathematical behavior, modify parameters, compare results, and receive immediate feedback. This integrated approach promotes active learning, strengthens conceptual understanding, improves problem-solving skills, and increases student engagement in undergraduate differential equations courses.

Graphical visualization: Graphical visualization is an essential component of learning differential equations because it helps students understand the behavior of solutions beyond symbolic calculations. ChatGPT, Wolfram Alpha, and Microsoft Math Solver can be effectively integrated to provide interactive graphical visualizations that enhance conceptual understanding. ChatGPT explains the mathematical concepts underlying graphs, such as slope fields, direction fields, phase portraits, equilibrium points, and solution curves, while guiding students in interpreting the graphical results. Wolfram Alpha generates high-quality visualizations of differential equations, including slope fields, solution curves, and phase-plane diagrams, allowing students to observe how solutions evolve under different initial conditions and parameter values. Microsoft Math Solver complements this process by plotting graphs of functions, providing step-by-step solutions, and enabling students to compare algebraic solutions with their graphical representations. By combining these AI-powered tools, students can dynamically explore the relationship between equations and their graphs, modify parameters, verify analytical solutions, and gain deeper insight into the qualitative behavior of differential equations. This integrated approach promotes active learning, strengthens visualization skills, and improves problem-solving abilities in undergraduate mathematics education.

Example: Consider the first-order differential equation $\frac{dy}{dx} = y - x$ with the initial condition $y(0) = 1$. ChatGPT explains the meaning of the equation and predicts how the solution changes with different initial conditions. Wolfram Alpha generates the slope field and plots the corresponding solution curve, enabling students to visualize the direction of the solution at every point in the plane. Microsoft Math Solver provides the analytical solution step by step and displays the graph of the solution. By comparing the symbolic solution with the graphical visualization, students develop a clearer understanding of the behavior of the differential equation and the effect of initial conditions on its solutions.

Virtual tutoring: Virtual tutoring with AI-powered tools such as ChatGPT, Wolfram Alpha, and Microsoft Math Solver provides an effective and personalized learning environment for undergraduate students studying differential equations. ChatGPT acts as an intelligent virtual tutor by explaining concepts in simple language, answering students' questions instantly, providing step-by-step solutions, and generating additional practice problems tailored to individual learning needs. Wolfram Alpha complements this process by performing accurate symbolic computations, solving ordinary differential equations, verifying solutions, generating graphical visualizations, and helping students understand the mathematical behavior of solutions. Microsoft Math Solver further enhances virtual tutoring by allowing students to capture handwritten or printed equations using a mobile device, after which it provides step-by-step solutions, explanations of solution methods, and links to related learning resources. Together, these AI tools create an interactive, self-paced, and student-centered virtual tutoring system that supports continuous learning beyond the classroom. They improve conceptual understanding, strengthen problem-solving skills, provide immediate feedback, and increase students' confidence and engagement in learning differential equations, making them valuable educational resources in higher mathematics education.

7. Benefits of AI in Teaching Differential Equations:

- Develops conceptual understanding.
- Encourages self-learning.
- Offers immediate feedback.
- Minimizes students' mathematical anxiety.
- Reduces teaching time.
- Enhances student engagement.
- Accommodates different learning speeds.



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- Develops problem-solving skills.

8. Challenges:

- Excessive reliance on AI tools.
- Decreased manual calculation practice.
- Restricted internet access.
- Information privacy concerns.
- Insufficient of teacher training.
- Risk of incorrect AI-generated responses.

9. Recommendations:

- Utilize AI as a teaching assistant rather than a replacement for teachers.
- Promote conceptual understanding before using AI tools.
- Educate faculty members in AI-based teaching methods.
- Incorporate AI literacy in undergraduate curricula.
- Encourage ethical and appropriate use of AI.

10. Conclusion:

Artificial Intelligence has great potential to enhance the teaching and learning of Differential Equations at the undergraduate level. AI tools offer personalized learning, visualization, instant feedback, and interactive problem-solving experiences. Although AI cannot take the place of teachers, it acts as a valuable educational assistant. Effective integration of AI into mathematics classrooms can greatly improve students' understanding, engagement, and academic achievement.

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