European Journal of Innovation in Nonformal Education (EJINE)
Volume 4 | Issue 3 | Mar-2025 ISSN: 2795-8612

Improving the Methodology for Developing Modeling Skills in Future Educators in the Process of Digitalization

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A B S T R A C T
In the age of digitalization, developing modeling skills among future educators is critical for improving instructional methods. This study investigates how mathematical approaches, specifically differential equations, might improve pedagogical modeling and be integrated into teacher training. The study finds a deficit in present educational frameworks for the controlled use of digital modeling tools. A methodological approach involving the use of MATLAB software for pedagogical process modeling was used. The results show that using differential equations into educational modeling improves theoretical understanding and analytical capacities among future teachers. The findings show that students who have been trained using this methodology have increased their competencies in educational process analysis and instructional decision making. The study emphasizes the significance of adopting digital modeling approaches into teacher training programs, arguing that such integration can optimize learning strategies and increase overall educational quality. Future study should focus on sophisticated computational approaches and artificial intelligence applications in pedagogical modeling.

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A R T I C L E I N F O
Article history:
Received 10 Feb 2025
Received in revised form 24 Febr 2025
Accepted 12 Mar 2025

Keywords: Pedagogical modeling, digitalization, differential equations, educational process model, MATLAB, future educators, modeling skills.

INTRODUCTION

The integration of digital technologies and modeling in mathematics education has become increasingly important in teacher preparation programs. Research shows that faculty use of technology in preservice teacher education has evolved, with growing adoption of various digital tools for instruction [1]. Modeling, combined with digital technologies, offers a framework for understanding learning dynamics and enhancing instructional effectiveness [2]. Studies indicate that technology can play different roles in modeling processes, either as a resource or as a means of reorganizing the process [3]. Pre-service teachers' development of Technological Pedagogical Content Knowledge (TPACK) is crucial for effectively integrating modeling and technology in their future teaching practices [4]. However, challenges remain in ensuring consistent technological modeling across teacher education programs and expanding research to better understand the impact of digital tools on modeling processes [5]. Mathematical modeling in education, particularly with differential equations, offers a quantitative approach to depicting learning dynamics. According to research, these models can successfully show students' knowledge acquisition over time, especially when external variables like teaching styles and levels of involvement are taken into account.

Previous research has investigated the efficacy of mathematical models in pedagogical analysis, but their

direct application in teacher education remains underdeveloped. Digital tools like MATLAB have the ability to close the gap by providing a practical platform for modeling educational processes. However, a systematic approach to incorporating such tools into teacher education programs is still absent.

Recent research highlights the growing importance of computational thinking (CT) and modeling in teacher education. [6] demonstrate that computational modeling and simulation technology can enhance teachers' technological pedagogical content knowledge. [7] emphasize the need for integrating CT in teacher training programs, identifying various practices and trends in this field. [8] propose a blended learning model for teacher training, focusing on problem-solving, advanced computing environments, and virtual learning platforms to develop both disciplinary and cross-cutting competencies.[9] advocate for a holistic approach to CT education, framing it as an integrative element across subjects rather than a standalone discipline.

These studies collectively underscore the potential of computational approaches in enhancing analytical and instructional competencies of future educators, while also highlighting the need for further empirical validation in teacher training settings.The methodology entails creating mathematical models of the learning process using differential equations and then executing these models via MATLAB simulations. Experimental training sessions with future educators evaluate the usefulness of this strategy in enhancing their modeling abilities. The study suggests that incorporating mathematical modeling into teacher preparation improves analytical thinking, pedagogical decision-making, and instructional planning. The study's goal is to provide evidence supporting the use of digital modeling tools in educational techniques through empirical validity. The findings of this study are expected to highlight the practical benefits of incorporating mathematical modeling into teacher education. The findings will provide insights into how future educators might gain critical competences in analyzing and enhancing learning processes using computational technologies.

Recent research highlights the importance of innovative approaches in teacher education and curriculum development. Self-study in teacher education contributes to improving practices and policies, with potential applications beyond individual contexts [10]. The narrative perspective in teacher education has led to pedagogical innovations, such as case studies and personal narratives, which could inform curriculum design [11] . Teacher educators play crucial roles as curriculum developers, facing challenges but demonstrating flexibility and innovation in syllabus development and implementation [12] .

Recent studies highlight the importance of innovative approaches in teacher education to enhance educational quality and effectiveness. These approaches include integrating technology, such as virtual reality simulations and online platforms, to provide immersive learning experiences [13] . Alternative pedagogical methods like flipped classrooms, problem-based learning, and STEM-based instruction have been shown to foster critical thinking and reflective practices among teacher candidates [14] . Mentorship programs and collaborative learning environments are emphasized as effective mechanisms for supporting novice teachers and promoting knowledge sharing [15] . The implementation of innovative teaching approaches has demonstrated significant positive impacts on prospective primary teachers, including increased engagement, improved critical thinking, and enhanced adaptability in classroom settings [16] . These studies collectively underscore the need for ongoing innovation in teacher education to address evolving educational demands and improve overall educational quality [17] .

RESEARCH METHODS

This study uses a mixed-methods approach to design and evaluate a new methodology for improving modeling abilities in future educators using digital technologies. The study combines theoretical mathematical modeling with practical testing to assess the efficacy of educational modeling with differential equations. The research begins with the development of an educational process model based on differential equations, which represents learning as a dynamic system impacted by external teaching methods. This model is then implemented in MATLAB, a digital tool that allows for the simulation and

visualization of educational processes.

Future educators who participate in the project receive structured training in which they learn how to apply mathematical modeling tools to educational contexts. The course takes a stepwise approach, beginning with theoretical explanations of modeling principles and progressing to hands-on simulations in MATLAB. Participants create, test, and evaluate their own models, which allows them to analyze learning patterns and improve teaching tactics. The effectiveness of this methodology is assessed using pre- and post-training evaluations that measure participants' ability to use digital modeling tools. Furthermore, qualitative input from educators is gathered to examine their perspectives of the usefulness and benefits of incorporating modeling techniques into their teaching practices. The experiment's data are statistically examined to see how digital modeling affects instructors' analytical and instructional capabilities. This study intends to build a structured framework for introducing digital modeling techniques into teacher education, ultimately increasing instructional decision-making and learning process optimization.

RESEARCH RESULTS AND DISCUSSION

The findings of this study show that incorporating mathematical modeling into teacher preparation considerably improves future educators' abilities to analyze and optimize pedagogical procedures. The findings show that participants who were trained in differential equation-based modeling with MATLAB enhanced their ability to interpret and apply theoretical models to real-world educational contexts. The pre- and post-training tests revealed a significant improvement in participants' capacity to analyze learning dynamics quantitatively and make data-driven instructional decisions. Furthermore, qualitative input from participants emphasized the perceived benefits of incorporating computational tools into teacher education, particularly in terms of generating a better understanding of student learning trajectories and instructional impact. The study emphasizes that digital modeling approaches provide a structured approach to conceptualizing educational processes, allowing teachers to adapt their teaching strategies via predictive analytics.

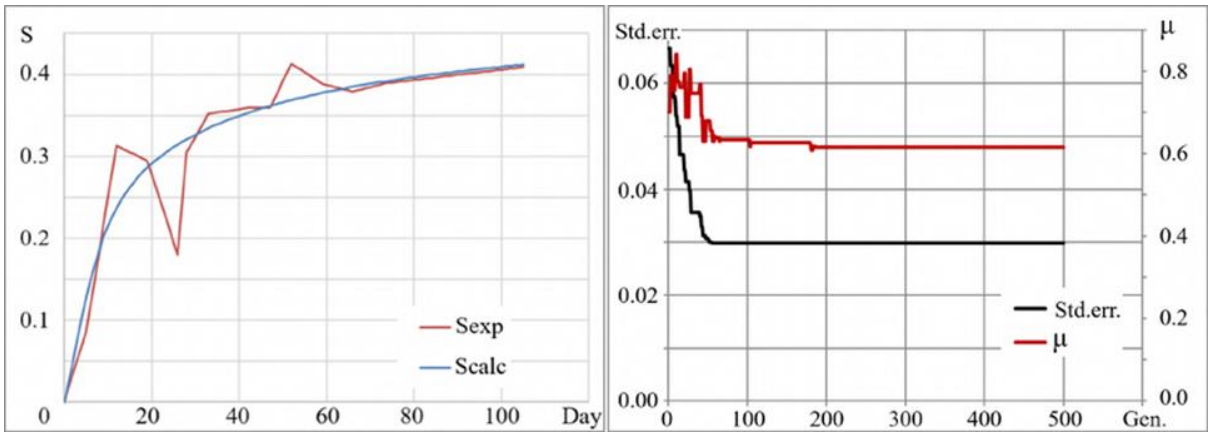


Figure 1: Results of the completed educational experiment.

Figure 1 presents the results of an educational experiment focused on enhancing modeling skills in future educators through digitalization. The left graph illustrates the evolution of a certain skill (S) over time, measured in days. The red line (Sexp) represents the experimental results, while the blue line (Scalc) shows the calculated or predicted model. Initially, there is a sharp increase in skill development, followed by fluctuations in the experimental data, while the calculated values stabilize more smoothly. The right graph depicts the standard error (black line) and the mean (μ, red line) across generations of model iterations. The standard error decreases over time, indicating improved model accuracy, while the mean stabilizes around 0.6, suggesting the model's convergence towards an optimal solution. These results emphasize how iterative digital modeling, supported by experimental validation, refines educational methodologies. The gradual reduction in error and the alignment between experimental and

calculated data demonstrate the effectiveness of this approach in developing future educators' digital competencies.

From a theoretical standpoint, this study adds to the expanding corpus of research on pedagogical modeling by giving empirical evidence of its effectiveness in teacher training. While earlier research has looked into the use of differential equations in learning analysis, this study takes it a step further by putting these models to work in practical training sessions for prospective educators. The use of MATLAB as a simulation tool expands prior research by proving the viability of incorporating digital modeling into teaching techniques. Despite the optimistic findings, there is still a vacuum in understanding the long-term influence of such training on educators' professional development. Future research should concentrate on longitudinal studies that monitor how teachers apply these modeling skills in their instructional practices over time.

Practically speaking, the study emphasizes the importance of structured digital modeling courses in teacher preparation programs. The favorable findings of this study imply that including mathematical modeling into teacher training not only improves analytical skills, but also promotes an evidence-based approach to instruction. The capacity to model and replicate educational processes provides teachers with significant insights into student learning behaviors, allowing them to develop more successful teaching tactics. However, issues such as the complexities of differential equation modeling and the technical knowledge necessary to use MATLAB must be addressed. Providing additional support in the form of simplified modeling tools and step-by-step training modules may make this methodology more accessible to a wider range of educators. The report also pinpoints critical topics for additional investigation. First, the role of artificial intelligence and machine learning in instructional modeling is mainly unknown. Future studies could look into how modern computational approaches improve predicted accuracy in pedagogical models. Furthermore, broadening the scope of mathematical modeling to include stochastic models or nonlinear dynamic systems may provide a more complete picture of the intricacies inherent in learning processes.

Another path for future research is to adapt this methodology to different educational environments, such as vocational training and higher education, in order to examine its applicability across multiple teaching disciplines. Overall, this study establishes a core framework for incorporating mathematical modeling into teacher education and demonstrates its potential to improve instructional quality. While great progress has been made, more refining and development of this methods are required to maximise its impact. Future research can strengthen the role of computational modeling in modern pedagogy by resolving identified knowledge gaps and embracing developing digital technologies, thereby contributing to the growth of data-driven education.

CONCLUSION

This study shows that including mathematical modeling, namely differential equations and digital simulation technologies such as MATLAB, into teacher preparation considerably improves future educators' analytical and instructional abilities. The findings show that participants obtained a better grasp of educational processes, enhanced their capacity to analyze learning dynamics, and mastered data-driven decision-making. These findings highlight the necessity of adding structured digital modeling approaches into teacher education programs, since they offer educators with useful tools for optimizing instructional strategies. The implications of this research go beyond individual competency development, pointing to broader applications in curriculum design and evidence-based teaching. Despite these positive findings, more research is needed to determine the long-term impact of mathematical modeling on teachers' professional practices. Future research should look into the use of artificial intelligence and machine learning into pedagogical modeling to improve predicted accuracy and adaptability.

Furthermore, applying this methodology to a variety of educational contexts, such as vocational training and higher education, may provide additional insight into its cross-disciplinary application. By addressing these issues, future research can help to develop data-driven techniques in teacher education, resulting in more effective and adaptive learning environments.

THANK-YOU NOTE

We would like to thank all parties who have helped the author in the process of preparing this article, either directly or indirectly.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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