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<https://kerjournal.com/>**Artificial Intelligence in Teaching and Learning Mathematics**Senad ORHANI<sup>1\*</sup>**Faculty of Education, University of Prishtina****Abstract**

The rapid advancement of technology, such as artificial intelligence (AI) and robotics, has affected all industries, including education. Artificial intelligence is being successfully applied in some educational cases and is improving student learning and development as well as teacher performance. Learning math is considered a great challenge for many students. The advancement of computer technologies, in particular, artificial intelligence (AI), is providing an opportunity to tackle this problem by diagnosing students' learning problems individually and providing personalized support to maximize their learning performance. mathematics. The purpose of this article is to provide an overview of the Artificial Intelligence (AI) knowledge being used in contemporary teaching methodology in mathematics. The results from the exploratory study have the potential to provide relevant knowledge about AI in the teaching and learning of the subject of mathematics. These findings may inform further investigations to support learning design and assessment in learning progression based on artificial intelligence techniques.

**Keywords:** Artificial Intelligence, mathematics, teaching and learning.

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**1. Introduction**

Artificial intelligence (AI) has the practical objective of designing and implementing systems whose behaviours seem intelligent to the eyes of human observers, seeing the system, one can legitimately assume that its behaviour is due to some kind of reasoning. An interrelated theoretical objective is to model

<sup>1</sup> *Corresponding author:* senad.orhani@uni-pr.edu  
ORCID: <https://orcid.org/0000-0003-3965-0791>

knowledge in an operational way. This implies a clear identification of what knowledge consists of and the ways in which it can be represented. For this reason, any research and development in AI implies epistemology, explicitly or action. Thus, intelligence in the expression "Artificial Intelligence" basically means that the implemented models enable a machine to solve problems, in the sense that the solutions to these problems are not a priori coded, but that they were originally built by the machine (Balacheff N., 2007).

In general, AI aims to create machines capable of solving problems that seem difficult and complex to human society. Such problems may be related only to thought processes and reasoning skills, or may refer to the appearance of a certain behaviour that seems intelligent (Russell & Norvig., 2009). Apple's Siri voice assistant, Amazon shopping recommendations, travel sharing on Uber and Google translate are examples of how AI has entered our daily lives. This is already having an impact on education.

Since all cognitive areas of education are very closely related to the concept of AI, it offers numerous opportunities for student engagement that cannot be found in extracurricular lectures within the classroom environment. The purpose of artificial intelligence is to represent human intelligence, to support communication between the user and the system during problem solving. The goal of intelligent systems is to create content that effectively adapts to the learner's learning knowledge and skills to optimize learning. It is universally known that AI would be the source and cause of the improvement of the classroom teaching methodology (Intel, 2020). All of this is good news for teachers, as AI can be a great ally for a teacher. However, some teachers fear the advancement of AI and that it may completely replace the role of teacher. The work of teachers is not in danger of being replaced by robots, while artificial intelligence programs can teach reading and writing or math, but the more complex division of social and emotional skills will always remain in the domain of humans.

Modern AI techniques involve the concepts of teaching and learning, as some systems are required to teach models and concepts, either autonomously or supervised through some form of instruction. The main contribution of Artificial Intelligence in the subject of mathematics is the provision of concepts, methods and tools for the design of flexible and relevant computer-based systems for teaching and learning purposes. Such systems convey great expectations such as: direct

manipulation of abstract objects, personalized explanations, and intelligent microbots that allow exploratory learning (Balacheff, 1993).

Expectations regarding the usefulness and effectiveness of intelligence relate to the teaching and learning environment which covers many aspects among which the key ones are: developing more accessible knowledge, allowing more autonomy for students, assisting or eventually replacing teachers in some office.

Mathematics is an important part of education and teaching in our country. As a core subject in teaching in our country, it has always played an important role. However, with the passage of time, traditional methods of teaching mathematics may not stimulate students' interest in mathematics. Therefore, the purpose of this article is to provide a summary of the Artificial Intelligence (AI) knowledge that is being used in contemporary teaching methodology in the subject of mathematics. Also, the other purpose is to investigate the applications and possibilities of the main programs that provide services using artificial intelligence in mathematics education.

### **Literature review**

Mathematics refers to learning content which uses symbolic language to represent concepts such as number, quantity, space and structure. The subject of mathematics has been identified as a complex and challenging task that aims to enhance students' competence in problem solving. Several previous studies have reported that students generally find it difficult to complete math tasks, especially those that need to be solved in multiple steps. Therefore, researchers have made efforts to develop different learning strategies and tools to improve learning outcomes in mathematics. They have also noted the importance of identifying factors that affect student performance in learning mathematics, such as insufficient prior knowledge and lack of personalized support for students in the individual form. Meanwhile, the advancement of artificial intelligence (AI) has provided a tool to address these problems. (Bray & Tangney, 2017; Civil & Bernier, 2006; Paras, 2001; Stephan, et al., 2015; Acharya, 2017; Davadas & Lay, 2017; Chen, Xie, & Zou, 2020).

Hwang et al. (2020) have identified several AI roles in education, as an intelligent teacher, caregiver, learning tool and partner, as well as educational policy-making advisor (Hwang, Xie, Wah, & Gasevic, 2020). Regarding the role of the intelligent teacher, the use of AI technologies

helps to simulate the intelligence of teachers to provide personalized guidance, feedback or support to students during the learning process, has been demonstrated by several researchers. For example, Hwang and other authors (2020) developed an adaptive learning system for math courses, taking into account students' cognitive and affective performance individually (Hwang, Xie, Wah, & Gasevic, 2020).

Researchers have also shown that in the 21st century, in addition to imparting knowledge, it is important to encourage students to think at the highest level, such as questioning skills, critical thinking, problem solving and creative thinking, therefore mathematics is the foundation of these skills. Several previous studies have highlighted that in mathematics education, it is important to support students to learn to think critically, communicate with others, solve problems and build knowledge, while also providing them with mathematical concepts and methods. (Demir & Basol, 2014 ). Some researchers have further pointed out that the use of AI technologies to analyse the learning status or behaviours of students enables the development of intelligent teachers who are able to provide individually effective interventions for students to improve their student performance. their learning and motivation. For example, one study by Xie et al. (2017) used the genetic algorithm to implement a personalized e-learning system to provide personalized curriculum development recommendations for students by promoting their learning performance. (Xie, et al., 2017). Another example is the use of AI technologies (e.g., unsupervised machine learning method) in the development of student models for predicting students' commitment or individual learning status in mathematics. (Tang, Chang, & Hwang, 2021).

In 2013, Arnau et al. designed an intelligent tutorial system for learning the arithmetic and algebraic way of solving word problems. Hypergraph-based problem solver (HBPS) was able to reinforce the translation of a problem into algebraic language or provide an arithmetic way of solving a problem. The system uses hypergraphs, easy for users to understand, to present the analytical reading of a particular problem, as well as to present a solution process, with many alternative solutions. HBPS also provides automatic feedback and suggestions when the user makes a mistake (Arnau, Arevalillo-Herráez, Puig, & González-Calero, 2013). Also in 2010, Beal et al. conducted three studies with high school students to evaluate AnimalWatch, an intelligent arithmetic and fractional learning system. The software relied on artificial intelligence algorithms to provide personalized support for students individually. AnimalWatch features word problems,

from the easiest to the most challenging, designed to train the user in basic computational and fractional skills. The AI is able to assess the student's abilities for each topic and respectively give useful suggestions or move on to a new mathematical topic. Overall, the results of the studies encouraged the hypothesis that software can be a useful and motivating educational tool (Beal, Arroyo, Cohen, Woolf, & Beal, 2010). Matsuda and VanLehn (2005) proposed an intelligent teaching system to improve the teaching of the geometry theorem that is proved by construction. Advance Geometry Tutor starts with a certain theorem of the geometry problem and the corresponding figure. The user is allowed to draw line segments in the figure to prove the theorem. The teacher gives comments and instructions that the student should follow through the messages window. The postulate browser window contains a list of postulates that can be used by the student for authentication. Finally the student can see the whole procedure that must be followed step by step to reach the test in the conclusion part (Matsuda & VanLehn, 2005). Another AI service is the MathTutor system, which provides step-by-step suggestions when solving problems using teacher instruction tracking. These teachers are able to assess students' problem-solving behaviour as well as provide multi-strategy problem-solving guidance. MathTutor, which is an open access website, also provides detailed performance data for each student, available to teachers or parents. Feng et al. (2008) proposed an intelligent learning system designed to predict students' math skills. The ASSISTment system is a combination of computer-based learning and standardized tests. If the student solves the given problem correctly, a new problem is given. If the student answers incorrectly, the system offers a small tutorial session, where the student is given the problem divided into subproblems to progressively reach the solution. According to researchers, the model can even do a standardized test (Feng, Beck, Heffernan, & Koedinger, 2008). Craig et al. (2013) proposed ALEKS, a web-based learning system with artificial intelligence components, as a method of intervening in after-school settings to improve mathematical skills. The intelligent tutoring system administers a test to assess the student's initial state of knowledge. The student can see a summary of his / her learning progress in each topic on a board. The student can then choose how to proceed from a list of types of problems he / she is ready to learn (Craig, et al., 2013).

## Methods and Materials

### Artificial intelligence techniques

Intelligent teaching systems incorporate artificial intelligence techniques in order to mimic a human teacher. These expert systems are able to assess student skills, provide examples and solved exercises for practice on each topic, and provide immediate and personalized feedback to students.

We are presenting some of the techniques used in AI:

- **Rule-based reasoning:** is a special type of reasoning that uses "if-else" statements. Intelligent teaching systems that adopt rule-based reasoning use logical connections such as AND, OR, NOT, etc. to form logical functions. The essential components of these systems are the rule base, the inference engine, which uses the knowledge provided by the rule base, working memory, where known facts are stored, and the mechanism of explanation (Prentzas & Hatzilygeroudis, 2007).
- **Case-based reasoning:** uses examples of problems encountered in the past to solve new problems. Case-based reasoning systems consist of the following parts (Alves, Amaral, & Pires, 2008):
  1. taking similar cases experienced in the past,
  2. reuse of cases by integrating solutions from cases received,
  3. reviewing or adapting the solution and
  4. keeping the new solution validated
- **Neural networks:** represent a different approach to artificial intelligence inspired by biological neural networks. Network activation flows from the input layer through the hidden (middle) layer, then to the output layer. Each link is related to its weight. The weights of a neural network are determined by a training process with empirical data. The performance of neural networks is also sensitive to the number of neurons (Ding, Li, Su, Yu, & Jin, 2013).
- **Constraint-based modelling:** constraint-based model tutors use student errors to construct a student model represented as a set of constraints violated or not. Each constraint consists of three components (Ma, Adesope, Nesbit, & Liu, 2014):
  1. a condition of importance that indicates when the restriction is applicable,
  2. a condition of satisfaction and
  3. a reaction message to the student's mistakes

### Artificial intelligence techniques

One of the features of artificial intelligence is that it is providing teachers and schools with innovative ways to understand how their students are progressing, through:

- **Personalized learning:** Managing a classroom of many students makes personalized learning almost impossible. However, AI can provide a level of differentiation that adapts learning specifically to a student's strengths and weaknesses individually (Marr, 2018).

- **Teacher help:** Teachers not only teach; they also spend hours evaluating documents and preparing future lessons. However, some tasks, such as writing on paper, can be performed by robots, giving teachers a lighter workload and more flexibility to focus on other things (Nelson, 2018). Machines can now evaluate multiple choice tests and are close to being able to manually evaluate written answers (Marr, 2018).
- **Teacher teaching:** Artificial intelligence makes available to teachers complete information at any time of the day. They can use this information to further their education in such things as learning foreign languages or mastering complex programming techniques (Nelson, 2018).
- **Connecting everyone:** Because AI is computer based, it can connect with different classes around the world, fostering greater collaboration, communication and collaboration between schools and students (Nelson, 2018).

### AI applications for the subject of mathematics

Educational applications harness the power of AI to enhance learning in students of all ages, from elementary school to university, and empower both the learner and the teacher with more ways to achieve their educational goals. Below we present some of the educational applications for the subject of mathematics enabled by artificial intelligence:

- **Ster Thinkster Math:** Thinkster Math is a learning application that combines true math curriculum with a personalized teaching style. She uses artificial intelligence and machine learning in their math teacher app to visualize how a student is thinking while working to solve a problem. This allows the teacher to quickly discern the areas of thinking and logic of a student that have caused them to stumble and help them through immediate and personalized feedback (Sennar, 2019).
- **Rain Brainly:** Brainly is a platform where students can ask homework questions and get automatic answers, verified by their peers. The site even allows them to collaborate and find solutions themselves. Mind uses machine learning algorithms to filter out the unwanted result (Sennar, 2019).
- **Ent Content Technologies, Inc.:** Content Technologies, Inc. (CTI) is an AI company that uses Deep Learning to create personalized learning tools for students, such as Just The Facts 101, where teachers import curricula into a CTI engine. The CTI machine then uses algorithms to create personalized texts and subjects based on core concepts. Cram 101 is another AI-enhanced example, where any textbook can be turned into a smart study guide, delivering small-sized content that is easy to learn in no time. It even generates multiple

choice questions, saving students time and helping them learn more effectively. (Turbot, 2018).

- **MATHiaU:** Similar to Thinkster Math, MATHiaU offers AI-based teaching tools for higher education students who feel overlooked in the classroom by educators. The app is guided by each student's unique learning process, keeps them aware of their daily progress, and helps teachers tailor lessons to meet each student's specifics (Couture, 2018).
- **Netex Learning:** Netex Learning allows teachers to design and integrate curricula across a range of digital platforms and devices. The easy-to-use platform allows them to create personalized student content that can be published on any digital platform. Teachers also receive tools for video conferencing, digital discussions, personalized assignments and lesson analysis that show visual representations of each student's personal growth (Sennar, 2019).

## Conclusions

As a result of the study, artificial intelligence in the subject of mathematics is mostly supporting students' personalized learning, defining it as an auxiliary role to support mathematics teachers, as well as supporting the learning process not only of cognitive aspects, but even of affective aspects. Although there are a host of unanswered questions about the role of AI and how it will be managed, there is little doubt that technology is inevitably linked to the future of education. Innovative applications will continue to be developed and researched, more programs and courses will include AI on similar topics, and existing curricula will be adapted to provide students with the skills they need in a world where a lot of work will be done by machines. We can say that it is quite difficult for computers and other "smart" AI machines to reach the point where in the future they will replace teachers in educating students. However, it is more than certain that changes may occur in future classes, as new technologies seem to have the potential to offer significant benefits to the teaching and learning of mathematics. Therefore, it is suggested that math teachers consider using AI applications to provide students with personalized guidance or support and to investigate the impacts of AI based learning approaches.



## References

- Acharya, B. R. (2017). *Factors affecting difficulties in learning mathematics by mathematics learners*. Int. J. Elem. Educ., 6, 8–15.
- Alves, P., Amaral, L., & Pires, J. (2008). *Case-based reasoning approach to adaptive web-based educational systems In Advanced Learning Technologies*. ICALT'08. Eighth IEEE International Conference on, 260-261.
- Arnau, D., Arevalillo-Herráez, M., Puig, L., & González-Calero, J. (2013). *Fundamentals of the design and the operation of an intelligent tutoring system for the learning of the arithmetical and algebraic way of solving word problems*. Computers & Education, 63, 119-130.
- Balacheff, N. (1993). *Artificial Intelligence and Mathematics Education: Expectations and Questions*. Biennial of the AAMT, 1-24.
- Balacheff, N. (2007). *Artificial Intelligence and Mathematics Education*. 14th Biennial of the Australian Association of Mathematics Teachers, 1-24.
- Beal, C. R., Arroyo, I., Cohen, P. R., Woolf, B. P., & Beal, C. R. (2010). *Evaluation of AnimalWatch: An intelligent tutoring system for arithmetic and fractions*. Journal of Interactive Online Learning, 9(1), 64-77.
- Bray, A., & Tangney, B. (2017). *Technology usage in mathematics education research—A systematic review of recent trends*. Comput. Educ. 114, 255–273.
- Chen, X., Xie, H., & Zou, D. (2020). *Hwang, G.J. Application and theory gaps during the rise of Artificial Intelligence in Education*. Comput. Educ. Artif. Intell., 1, 100002.
- Civil, M., & Bernier, E. (2006). *Exploring images of parental participation in mathematics education: Challenges and possibilities*. Math. Think. Learn., 8, 309–330.
- Couture, W. (2018). *How AI is disrupting education*. Disruptor Daily.
- Craig, S. D., Hu, X., Graesser, A. C., Bargagliotti, A. E., Sterbinsky, E., Cheney, K. R., & Okwumabua, T. (2013). *The impact of a technology-based mathematics after-school program using ALEKS on student's knowledge and behaviors*. Computers & Education, 68, 495-504.
- Davadas, S. D., & Lay, Y. F. (2017). *Factors affecting students' attitude toward mathematics: A structural equation modeling approach*. Eurasia J. Math. Sci. Technol. Educ., 14, 517–529.
- Demir, S., & Basol, G. (2014 ). *Effectiveness of Computer-Assisted Mathematics Education (CAME) over Academic Achievement: A Meta-Analysis Study*. Educ. Sci. Theory Pract., 14, 2026–2035.
- Ding, S., Li, H., Su, C., Yu, J., & Jin, F. (2013). *Evolutionary artificial neural networks: a review*. Artificial Intelligence Review, 39(3), 251-260.

- Feng, M., Beck, J. E., Heffernan, N. T., & Koedinger, K. R. (2008). *Can an Intelligent Tutoring System Predict Math Proficiency as Well as a Standardized Test?* EDM, 107-116.
- Hwang, G. J., Xie, H., Wah, B. W., & Gasevic, D. (2020). *Vision, challenges, roles and research issues of Artificial Intelligence in Education*. Comput. Educ. Artif. Intell., 1, 100001.
- Intel. (2020). *Artificial Intelligence Integration in Mathematics*. Department of School Education and Literacy, Ministry of Education, Government of India.
- Ma, W., Adesope, O., Nesbit, J. C., & Liu, Q. (2014). *Intelligent tutoring systems and learning outcomes: A meta-analysis*. Journal of Educational Psychology, 106(4), 901.
- Marr, B. (2018). *How is AI used in education: real world examples of today and a peek into the future*. Forbes.
- Matsuda, N., & VanLehn, K. (2005). *Advanced Geometry Tutor: An intelligent tutor that teaches proof-writing with construction*. AIED, 125, 443-450.
- Nelson, K. (2018). *The future of artificial intelligence in education*. TechWell.
- Paras, J. (2001). *Crisis in mathematics education. Student failure: Challenges and possibilities*. S. Afr. J. Educ., 15, 66-73.
- Prentzas, J., & Hatzilygeroudis, I. (2007). *Categorizing approaches combining rule-based and case-based reasoning*. Expert Systems, 24(2), 97-122.
- Russell, S., & Norvig, P. (2009). *Artificial Intelligence: A Modern Approach*. Prentice Hall Press, USA.
- Sennar, K. (2019). *The artificial intelligence tutor – the current possibilities of smart virtual learning*. Emerj.
- Stephan, M. L., Chval, K. B., Wanko, J. J., Civil, M., Fish, M. C., Herbel-Eisenmann, B., . . . Wilkerson, T. L. (2015). *Grand challenges and opportunities in mathematics education research*. J. Res. Math. Educ., 46, 134-146.
- Tang, K. Y., Chang, C. Y., & Hwang, G. J. (2021). *Trends in artificial intelligence-supported e-learning: A systematic review and co-citation network analysis (1998-2019)*. Interact. Learn. Environ., 1-19.
- Turbot, S. (2018). *Artificial intelligence in education: don't ignore it, harness it!* Forbes.
- Xie, H., Zou, D., Wang, F. L., Wong, T. L., Rao, Y., & Wang, S. H. (2017). *Discover learning path for group users: A profile-based approach*. Neurocomputing, 254, 59-70.