Deep Learning in Math Education

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ABSTRACT

This scientific paper aims to present information about the use of Deep Learning in the field of mathematical education. In the review of the literature, a series of studies and applications of advanced technologies in the teaching of mathematics were identified. Several studies have shown that the use of deep models can identify specific difficulties of students and provide personalized feedback to improve learning outcomes. In addition, the use of innovative applications has shown the potential to make mathematics learning more engaging and interesting for students. In conclusion, the literature review has identified an increasing trend in the use of deep learning in the field of mathematics education. However, continuing research in this direction and expanding practical applications will contribute to our knowledge and improve teaching practices in this area.

Keywords: AI Technologies; Deep Learning; Math Education; Learners; Learning

INTRODUCTION

The teaching of mathematics has experienced great changes in recent years, adapting to the challenges of an increasingly technologically advanced world. Advanced technology interventions, especially the use of deep learning (Deep Learning), have brought about a new paradigm in mathematics learning. This scientific paper aims to examine and analyze the use of immersive technologies in the context of mathematics education, addressing the potential and challenges that this use brings to the advancement of mathematics learning and teaching.

At a time when technology has changed the dynamics of society and knowledge, we are seeing an increase in interest in the use of artificial intelligence and deep learning in the field of education. This is especially important in the context of mathematics, a subject that can often present great challenges for students. The use of deep technologies, with their potential for discovering complex patterns and deep data analysis, can bring great innovations in improving the learning experience and developing students' analytical skills in mathematics.

Deep learning is a form of understanding-based learning. Learners can critically absorb new knowledge and ideas, integrate new knowledge and ideas into existing cognitive structures, make connections between multiple ideas, and transfer existing knowledge to new situations to make decisions and solve problems. Deep learning refers to the learning process and the learning situation of students. The focus is on students' deeper understanding of basic knowledge concepts and principles and their co-construction of learning content and knowledge.

In this context, our research will focus on identifying the benefits of using deep learning in mathematics teaching, exploring its applications in improving performance and increasing student motivation. To achieve these goals, we will analyze current studies and research, using an interdisciplinary approach to understand the impact of technology in depth in mathematics education.

This scientific paper aims to contribute to the existing literature by deepening our understanding of the role and potential of deep learning in the field of education and mathematics. Through this analysis, we hope to uncover the opportunities and challenges presented by this intersection of technology and mathematics education, providing a basis for further research and practical developments in this direction.

- **Identification problem**

In classroom learning under traditional pedagogy, students consider course content to be content that has nothing to do with their existing knowledge and experience. Students consider the course content as fragments or modules of irrelevant knowledge. Students cannot understand why and how to do this, they just memorize facts and imitate operating procedures. Students have great difficulties in understanding different concepts from the content of this book. The student always considers static knowledge as an authority. Students cannot consciously reflect on their learning goals and learning strategies.

- **Purpose of the study**

The purpose of this scientific paper is to explore and analyze the use of deep learning (Deep Learning) in the field of mathematical education. This research aims to address some challenges and examine the potential of using immersive technologies to improve the learning experience in mathematics. Here are some specific writing goals:

Identifying the benefits of learning performance: We seek to identify and analyze the benefits that the use of deep learning can bring in improving student performance in mathematics. This includes identifying specific student difficulties and providing personalized tutoring feedback.

Analysis of the overall impact of deep technology: Through in-depth analysis, we aim to understand the impact of using deep learning on a broader level, including changes in classroom dynamics, the teacher-student relationship, and the overall experience of teaching mathematics.

This scientific paper aims to contribute to the scientific discourse about the use of advanced technologies in mathematics education and to provide a basis for further research and practical developments in this field.

- **Research objectives**

The main purpose of this scientific research is to explore and analyze the use of deep learning (Deep Learning) in the field of mathematical education. This research aims to understand how immersive technologies can contribute to improving the learning experience and developing students' mathematical skills. To achieve this goal, the research will address several specific objectives:

Research objectives:

Analysis of current applications: Identification and analysis of studies and current applications of deep learning in the field of mathematics education to understand how this technology has been used so far.

Evaluation of effectiveness: Investigating the effectiveness of using deep learning in improving learning performance and developing students' mathematical skills.

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Analysis of challenges and risks: Identification and analysis of challenges and risks of using immersive technologies in the context of mathematics education, including ethical and technological issues.

These objectives are defined with the aim that the research will make a valuable contribution to the field of deep learning and mathematics education, providing a deeper understanding and new knowledge about the use of deep technologies in this context.

LITERATURE REVIEW

Research in deep learning can be traced back to the mid-1970s in Sweden when Ference Marton and colleagues investigated Swedish university students who were asked to read academic articles within a suggested time frame, followed by specific questioning about key passages. from articles (Marton, 1975; Marton & Säljö, 1976). Findings from recorded conversations with university students revealed two qualitative differences in learning outcomes. Some students tried to understand the essential pieces of prose from the articles by grasping and understanding what they were reading and trying to relate the content to prior knowledge. Another completely different learning style could be identified when the university students tried to memorize particular aspects of the articles. Marton and Säljö (1976) have described these qualitative differences in levels of learning "in terms of whether the learner is engaged in surface-level or deep-level processing." A superficial approach to learning thus involves minimal engagement with e.g. a task, usually focusing on memorizing or performing procedures that do not involve reflection or understanding. In contrast, a deep approach to learning includes e.g. a focus on the relationships between different aspects of content, with the aim of understanding and imposing meaning (Marton, 1975; Marton & Säljö, 1976).

From these introductory texts on deep learning, the development of the new learning science has been introduced to a wide audience by e.g. manual, providing deep insight into deep learning versus surface learning and how to use deep learning to design effective classroom learning environments in all subject areas. In the handbook, "How People Learn" Bransford, Brown, & Cocking, (2004), the authors state that one of the hallmarks of what they call the "new science of learning" is the emphasis on learning. with comprehension used in parallel with deep learning. However, students should have a deep foundation in factual knowledge as knowing facts is important for memorization thinking, and problem-solving, but new knowledge should be built from pre-existing knowledge and students should be encouraged to be active and take control of their learning. These authors challenge the view that memorization is equivalent to surface learning and they suggest that deep learning of subject matter helps learners to use factual information and transform it into usable knowledge in a problem-solving context by generating arguments and explanations. and drawing analogies with other problems (Bransford, Brown, & Cocking, 2004),.

In mathematics education, the debate over procedural understanding and conceptual understanding has deep roots (e.g., Hiebert & Lefevre, 1986; Star, 2005), and for many decades terms such as 'rote learning' and 'real understanding ' have colored the debate on learning. (Schoenfeld, 2007). In this context, 'rote learning' is often used in parallel with memorizing facts or procedures, bringing learning to the surface. 'Rote learning' is also used in parallel with terms such as procedural knowledge or procedural understanding (Hiebert & Carpenter, 1992; Hiebert & Lefevre, 1986), and instrumental understanding (cf. Skemp, 1976). "True understanding" is often used in parallel with deep learning and terms such as relational understanding (Skemp, 1976) and conceptual understanding (Hiebert & Carpenter, 1992; Hiebert & Lefevre, 1986). These researchers claim that a person's knowledge base consists of different types of knowledge such as conceptual and procedural knowledge and that this knowledge base can be characterized by qualities such as deep or surface levels of knowledge. A focus in deep learning, according to de Jong and Ferguson-Hessler (1996), will be on the qualities of teachers' knowledge.

As a pedagogical implication from Fauskanger and Bjuland's (2018) study, they suggest that it is important for in-service teachers (in the project this study is part of similar projects worldwide) to be aware of their learning characteristics. deep as well as their characterizations of ambitious teaching practices (Lambert et al., 2010) essential to the work of teaching by enhancing deep student learning. Ambitious teaching practices are used in instructional dialogues in which teachers and their students can engage with each other and share ideas and elaborate different views (Alexander, 2008), drawing on important attributes of a learning environment. in the classroom that promotes learning outcomes, e.g., lessons should be learner-centered, knowledge-centered, and community-centered (Bransford et al., 2004). A second pedagogical implication is related to the concept of deep learning. They suggest that attention be paid to this by discussing with teachers (the different concepts used to capture deep learning as both a product and a process). Fullan's (2013) deep learning (eg communication, collaboration critical thinking, and problem-solving) can be a starting point for such a discussion (Fauskanger & Bjuland, 2018).

In terms of computer artificial intelligence, deep learning refers to algorithmic thinking. Its essence is that the computer simulates the deep thinking of the human brain to realize the complex operation of data (Chi, et al. (2017). In the field of artificial intelligence, computer information processing is a process of automatic encoding and automatic decoding. It is a process from data mining and abstract recognition to optimal selection. The human brain processes information layer by layer. Computer artificial intelligence simulates the cognitive structure of the human brain to process complex information. Artificial intelligence does not only rely on data models. The process of artificial intelligence simulation from symbol acquisition, decoding, and connection establishment to optimal selection is also structured (Yusoff, et al. 2017).

AI technologies can significantly increase student engagement in mathematics education. For example, virtual reality (VR) and augmented reality (AR) applications provide engaging visual representations of abstract mathematical concepts. Mathematics is intrinsically linked to problem solving and AI can play a crucial role in developing students' problem-solving skills. Looking ahead, the integration of AI into mathematics education is poised to transform the way we teach and learn mathematics. As AI technologies continue to advance, we can expect more sophisticated virtual tutors, chatbots, and intelligent learning platforms. These systems will leverage natural language processing and machine learning to engage in meaningful conversations with students, answer their questions, and provide tailored explanations. Furthermore, AI can facilitate deep learning by connecting students with peers around the world, enabling them to exchange ideas, solve problems together, and develop a global perspective (Sinha, 2023).

Artificial intelligence (AI) has the potential to improve the teaching and learning of mathematics (Orhani, 2021). One approach is to use AI technologies, such as computer vision and deep learning, to explore mathematical concepts in historical and artistic world heritage sites. Another approach is to develop AI-based chatbots that engage learners in authentic teaching situations, enhancing their skills through practice and interaction. Additionally, AI can be used to create intelligent learning systems that personalize material for individual students, leading to increased learning outcomes and improved grades (Orhani, 2024). Furthermore, the use of task-oriented spoken dialogue systems can support play-based learning of basic mathematics concepts, providing multimodal interactions for early childhood education. These advances in AI have the potential to strengthen mathematics education and promote critical thinking and problem-solving skills (Qiu, 2022).

The study of Dalehefte and Canrinus (2023) proves in particular that the importance of content and quality of teaching) gives a valuable insight into how the conditions in teaching coexist and to what degree they support the internalization of students. basic and deep motivation and elaborations to foster deep learning. This theoretical background can help teachers develop their instruction towards deep learning by taking into account the needs of students, as well as the quality of teaching and the importance of content.

METHODOLOGY

This research paper will use a literature review methodology designed to identify and analyze the use of deep learning in the field of mathematics education. The methodology will include several key steps to ensure a systematic and relevant approach to the topic.

This literature review research methodology aims to provide a comprehensive and clear overview of the use of deep learning in the field of mathematics education, integrating and analyzing various sources to provide a valuable contribution to the existing literature in this field. the study.

- **Identification of resources**

Identification of sources used for literature search, including scientific databases, books, journal articles, and relevant conferences in the field of deep learning and mathematics education.

- **Selection of studies**

Selection of studies and articles that match the research foci and that provide a significant contribution to the topic. Defining selection criteria, including relevance, strength of argument, methodology used, and sensitivity to context of deep learning applications in mathematics.

- **Literature analysis**

In-depth reading and analysis of selected articles, identifying trends, key findings, and their implications for practice and research in the field of study. Evaluating resources to understand their strengths and weaknesses and to identify needs for additional research.

- **Systematization of information**

Organization and systematization of information found in the literature to provide a complete and clear overview of the field of study. Identifying trends, patterns, and different perspectives emerging from the literature to determine research focuses and goals.

MATERIALS AND METHODS

There are several AI (Artificial Intelligence) platforms and applications that have been developed to improve mathematics learning using deep learning techniques. Some of them are:

Duolingo is starting to break into the math field with their new platform “Duolingo ABC”, which focuses on teaching numbers and math signs to young children. The use of AI technology helps personalize the learning experience for each child, tailoring activities and lessons to their ability level.

Duolingo’s new math course aims to make “learning math” fun. Duolingo Math combines informative elements such as animations, interactive exercises, etc. to make the overall mathematics learning experience more engaging and dynamic. Now, with the help of the new Duolingo math course, you can easily learn math, and more than that, learning math has now become much more fun and interesting thanks to Duolingo. Duolingo Math comes with two options: one for beginners and one for intermediate students. Students who wish to learn mathematics at the primary level can choose introductory mathematics. Duolingo’s introductory math program is designed to provide students with a comprehensive understanding of the most rudimentary math topics. You can even choose such a program to improve your basics. Individuals who already have an understanding of elementary mathematics topics and wish to learn mathematics at a higher level may choose the intermediate program. The intermediate math program offered by this exam enhances everyday skills with more challenging exercises. These exercises are designed to challenge the human mind and, at the same time, increase your mathematical skills to a higher level (Duolingo, 2024).

IXL Learning provides an online learning platform for schools and students to improve their math skills. The use of AI technology in this platform helps identify the difficulties of individuals and provides personalized exercises and lessons for each student depending on their needs.

Gain fluency and confidence in math! IXL helps students master essential skills at their own pace through fun and interactive questions, built-in support, and motivating prizes (IXL Learning, 2024).

Khan Academy offers a wide range of math learning resources, including video lectures, interactive exercises, and tailored tests. Artificial intelligence is used to tailor exercises and lessons to each student based on their performance and the difficulties they encounter.

Students practice at their own pace, first filling in gaps in their understanding and then accelerating their learning. Created by experts, Khan Academy's library of trusted practices and lessons covers math, science, and more. Always free for students and teachers. With Khan Academy, teachers can identify gaps in their students' understanding, tailor instruction, and meet the needs of each student (Khan Academy, 2024).

Dream Box Learning is a math learning platform for children aged 4-14. The use of AI technology helps identify each student's ability level and provides exercises and activities tailored to their individual needs.

Dream Box Math helps students succeed no matter where they start. Personalize K-8 math learning with a supplemental curriculum that's more than just instructional support software. Dream Box Math is intelligently tailored to ensure that students, at every level, stay motivated and receive the right instruction at the right time, from day one. Learning is not linear, and neither is our approach. Dream Box tracks each student's interaction and assesses their strategies, then instantly adjusts learning and demands so each student can progress at the pace and learning path that's right for them. Dream Box gets results because it adapts based on strategy, not response. A powerful educational experience to inform instructional decisions. Dream Box provides actionable data that deepens educators' understanding of where students are, where they need to be, and how to get them there (Dream Box, 2024).

Prodigy is a math learning game that uses AI technology to help students improve their math skills. The game offers personalized challenges and exercises for each student, adjusting the difficulty and content based on their performance.

Prodigy offers 1500+ math skills ranging from simple to advanced. Students practice fluency and knowledge of basic concepts and routine procedures m and they interpret and understand what the question is asking. The team of education specialists who create the mathematics content are former teachers. Together, they regularly create content—researching learning standards and building content into small skills that students can practice on their way to learning mastery. Using their experience as classroom educators, they develop question prompts and video lessons to ensure students have accessible and appropriate scaffolding and content rigor. Educators and parents can use Prodigy as they work to support students' understanding of basic math principles to ensure that students not only understand new knowledge – but learn to apply it as well (Prodigy, 2024).

ALEKS (Assessment and Learning in Knowledge Spaces) is a personalized mathematics learning platform that uses artificial intelligence algorithms to identify the difficulties and knowledge levels of each student. With the help of deep learning, ALEKS provides an individualized learning program for each student,

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offering exercises and lectures that address their specific needs.

ALEKS is an artificial intelligence learning and assessment system that has been used by over 25 million students for math, chemistry, statistics, and accounting. After quickly and accurately determining each student's exact knowledge of a subject, ALEKS helps the student work on the topics they are ready to learn. ALEKS intelligence, content, and software are unique and individual, they are developed together and work in unison. ALEKS digital content provides comprehensive course coverage. Students who complete their ALEKS assignments are successful in their course. ALEKS AI was developed using billions of data points from student interactions collected over 21 years of successful learning from millions of students. This data is the data that enables the ALEKS research and development team to refine the intelligent machine responsible for ALEKS' unique ability to accurately and efficiently diagnose each student's knowledge and what they are ready to learn. The ALEKS machine is trained to efficiently identify the exact topics each student has mastered and is ready to learn based on their answers to a small number of questions selected by ALEKS based on their answers to all questions previous. When ALEKS provides the student with a ready-to-learn topic, ALEKS is almost always accurate. ALEKS Intelligence uses machine learning based on Knowledge Space Theory to efficiently develop and maintain a detailed map of each student's knowledge. ALEKS knows, at any moment, about each course topic, and whether the individual student has mastered that topic and is ready to learn it now. ALEKS facilitates super-effective learning by providing the students with a selection of topics they are currently ready to learn. Since the students are always working at the limit of their current knowledge, ALEKS students are not as frustrated or bored as they are when working with material that is too easy or too difficult for them. Instead, the student's confidence and learning momentum is built as they challenge, work with, and then master each new topic (Aleks, 2024).

CONCLUSION

The study of the use of in-depth learning in mathematics education is extremely important for the development of mathematics teaching and for the improvement of students' mathematical skills. Through the review of the literature and the analysis of the results, it is evident that in-depth learning has great potential to transform the way students learn and benefit from learning mathematics. At a time when technology is rapidly advancing, the use of artificial intelligence, machine learning, and deep algorithms are tools that can profoundly impact the learning experience. Content personalization, instant feedback, and information visualization are just some of the advantages of these technologies.

At the same time, the discussion has also brought to attention the challenges and opportunities of using technology in this field. The need for data security, the suitability of the technology for the educational context, and the inclusion of all students are some of the challenges that must be addressed to ensure a successful and sustainable use of these technologies.

At the end of this study, some essential points emerge that in-depth learning offers great opportunities for improving mathematics learning. Personalization of content, instant feedback, and competitive elements are just some of the aspects that can positively influence student motivation and achievement. However, using technology in deep learning is not without its challenges. Careful attention is needed to data security, ethical use of algorithms, and adaptability to the different needs of students and teachers. Although the study has provided a clear overview of the benefits and challenges of using deep learning in mathematics education, there is still room for further research to expand our understanding and find innovative solutions to current problems.

In conclusion, the use of deep learning in mathematics education has great potential to improve the learning experience and increase students' mathematical skills. However, this use must be made carefully and appropriately, including an assessment of the needs and challenges of each particular learning context. By continuing to invest in research and innovation in this area, we can progress towards more effective and sustainable mathematics education for all.

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