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Education Technology, Artificial Intelligence, and the Mathematics Classroom

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The understanding and learning of mathematics has often been considered a big challenge for many students. More recently the level of mathematical preparedness for students entering tertiary education in Ireland has continued to generate widespread concern both in the general public and the academic community. Reporting on these deficiencies in basic mathematical skills in incoming undergraduates is well documented such as O'Donoghue (2002), Gil et al (2010), Ní Shé et al (2015) and Lawless et al (2016). Combined with this, new computing and technological developments have emerged and data-intensive technologies, such as Artificial Intelligence (AI). There is a need to develop maths education in a more engaging and stimulating way for the 21st century learner through the use of technologies and in particular mobile technologies. This article presents an overview of AI in mathematics education.

Critical and independent thinkers need to be developed for the modern world rather than simply the rote learning of mathematics. Through the use of technology, which learners are already using regularly, such as mobile phones or tablets, learners have the opportunity to upskill and engage with maths on a more frequent basis in new learning environments outside the classroom.

Ally (2009) details numerous innovative ways in which digital technologies can be used to promote learning in both inside and outside of the classroom environment. Some recent reviews on the use of educational technology applications in the role of maths learning showed a general positive effect when compared to traditional classroom methods on students' math achievement (Cheung & Slavin, 2013; Li & Ma, 2010). In their research on the timing of feedback on homework, Kehrer et al. (2013) concluded that the timing of feedback has a role to play in improved learning. When feedback is immediate the students learned more than

waiting to receive similar feedback at a later time. Zhang et al (2015) conducted an exploratory study on a group of fourth grade students where approximately half the students were either at-risk students or had disabilities. The students made use of three maths apps that supported their learning through different scaffolding strategies in the area of decimals and multiplication. The pre and post tests results showed that the use of the maths apps help improve the student mathematical learning.

However recent advancement in new computer technologies, particularly in the area of Artificial Intelligence provides new opportunities to help influence and enhance student engagement and mathematical learning. Artificial intelligence or AI refers to the field of computer science research aimed at developing software technologies or systems that make a computer or robot think and act like a human. The oxford living dictionaries defines Artificial Intelligence as

> *"The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."*

AI is increasingly used to impact our everyday lives from using search engines like google chrome, talking with Apple's virtual assistant Siri on our phones, using predictive text applications on our emails and messaging systems to its many using on the different social media platforms. The size of the Artificial Intelligence education market in the US alone exceeded $2billion in 2021 and is expected to grow at a compound annual growth rate of over 45% from 2022 to 2030 (gminsights.com, 2022).

With the growth of AI technology, its uses in the field of education and teaching have been gradually increasing. The advancement of emerging technologies, like AI, provide an opportunity for teachers to improve and complement their teaching styles and for students to improve their learning and knowledge. Xie et al., (2019) argues that the application of AI to education opens the door to the development of personalized supports and adaptive eLearning systems for the learner. It has the potential to customize the learning for the user and allow the user the ability to interact, collaborate and provide more meaningful experiences in online, mobile or blended learning. The use of digital technologies together with appropriate pedagogical approaches allow new and different ways of engaging the learner with mathematical concepts and processes (Calder and Campbell 2016).

AI has been used to some extent in mathematics education for a few decades now through various software such as computer algebra systems. However, in recent years and with the rapid development of the age of big data, modern AI techniques are finding their way more and more into the world of education. Many of these different AI techniques are being used to help the user gain a better understanding of mathematics. Hwang et al (2020) identified many ways AI can be effective in the area of education from learning tools to intelligent tutors. Several researchers have demonstrated the ability of intelligent tutors to simulate instructors' intelligence in providing supports, feedback and personalized help to the learner.

For example, Roschelle et al. (2016) used the online tool ASSISTments to explore the use and impact of technology on the mathematical learning of seventh-grade mathematics students. The tool assists students with hints and timely feedback as they complete the various homework tasks as well as providing information on the students work to the instructor. The results were positive, with the students that made use of the online tool showing a significant increase in their scores on an end of term mathematics assessment as compared to a control group that worked with the existing homework approaches. The students with previous low attainment in mathematics benefited the most from the online tool and the non-judgemental feedback given by the online platform showed to be an ideal space in nurturing their mathematical confidence and skills.

Hwang et al (2020) developed an adaptive learning system by taking into account the learners cognitive and affective status. Pai et al. (2020) examined the pedagogical effectiveness of an intelligent tutoring system designed to help improve the multiplication and division skills of fifth grade students. Survey feedback found that the intelligent tutoring system not only improved the mathematical learning of the fifth graders but also increased their motivation to learn. According to Gao (2020), artificial Intelligence enables the learner to improve both their cognitive and mathematical skills in the process of learning. The 21st century learner are more inclined to explore new knowledge and learn in their own time and should take advantage of the potential new benefits that the emerging technologies can bring, in improving their learning skills. The continued advancement of digital and computing technologies provides new ways to help improve teaching and learning. There are many potential benefits for example of using mobile technologies for learning such as facilitating contextual learning, as well as personalising the learning for the student as detailed by Cochrane (2010).

Research suggests that since experts' knowledge is built around core concepts and big ideas (Bransford et al., 2019) it follows that the curriculum related to understanding what AI is, should be organised in the same way. As stated previously, AI and machine learning are shaping our world at a very fast pace and the technologies are challenging us to rethink and redesign our lives as well as mathematics education. With the recent discussion about ChapGPT we are certainly presented with a challenge. However this may be a very good challenge, because it is forcing us to look for creative and original mathematical thought, and not just what these systems do, which is just a rewording and a regurgitation of the sources that they have been fed.

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