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Q. What impact do you think online learning has had on the way students learn to solve mathematical problems?

The notion of technology-enhanced learning in mathematics is nothing new; educators have long been supplementing traditional classroom-based teaching methods with web-based media in some form or another. Over the past year, however, social distancing requirements introduced in response to the ongoing COVID-19 pandemic have brought about a substantial change in the extent to which these methods are used, with academic institutions now having to deliver courses wholly through online means. As one of the many students now relying solely on technology to gain an education, I have noticed a shift in my attitude towards online learning, particularly as it pertains to the development of mathematical problem-solving skills. All too often e-learning is branded as the epitome of a quality education, preconceived ideas of how it might be realised and our reverence for the stylish and futuristic leading us to become biased without considering its efficacy in a practical sense. Can online learning ever serve as an effective substitute for a conventional classroom when it comes to the acquisition of problem-solving skills?

Online learning is a rather broad concept, the electronic media it employs ranging from communication platforms facilitating online lectures and learning management systems such as Moodle to web pages hosting animations and online simulations of dynamic mathematical problems. The impression we so often get is that for every need, there exists some complementary web-based provision, but do the options afforded to us by electronic/web-based media allow us to actualise those factors deemed crucial when learning how to solve problems? To answer this, we must first identify what learning to solve mathematical problems actually involves. Approaches to mathematical problem-solving might vary, but a feature shared by the vast majority is the acknowledgment that ‘active engagement’ is paramount to the development of an individual’s problem-solving skills. This often constitutes collaboration with peers so as to gain exposure to different thought processes and practice in both posing and solving problems in order to acquire an arsenal of useful techniques and cultivate one’s own mathematical intuition through experience.

So, is this notion of ‘active engagement’ facilitated by online learning methods? As it stands, the reality of how mathematics students experience e-learning deviates somewhat from the ideal we often imagine. For many, it is realised as a series of video-recorded lectures, worksheets and literature recommendations all stored on their respective course pages hosted by a learning management platform. The missing ingredient? Interaction with course instructors and fellow students. Whilst email, module chats and forums exist as means to ask for insight or feedback on a particular strategy, back-and-forth communication conducted online cannot compare with the convenience of face-to-face counsel, anecdotal evidence suggesting that a lag in response time can play a part in students becoming discouraged and giving up (Smith and Ferguson, 2005) despite the necessity of perseverance in order to learn from a given problem.

Of course, communication platforms such as Microsoft Teams do exist and are the primary means used to host classes in real time, allowing a degree of interaction between students and course instructors. However, the temptation of switching the camera and microphone off so as to maintain anonymity can prevent students from actively participating, defeating the purpose of synchronous online learning as a substitute for face-to-face interaction. Throughout the MA3E7 module we were routinely encouraged to discuss our ideas concerning a particular problem or problem-solving strategy with fellow students via virtual discussion ‘rooms’. Although this online approach to group work might seem the obvious analogue to a physical classroom discussion, I would often sense a general discomfort surrounding this form of communication, many of the collaborative sessions being punctuated with long bouts of silence during which everyone worked by themselves, despite having been explicitly asked to share our thoughts with one another. A traditional classroom environment would likely have encouraged a more collaborative dynamic. Of course, this unease could be attributed to our relative inexperience with the platform, but since I did not observe much of a change as the term progressed, this is unlikely to have been the case.

Moreover, whilst online learning doesn’t actively discourage practice, the onus to attend online workshops, seek out problems independently and practise applying techniques is on the student themselves. In a traditional classroom setting, even those students who might be less diligent are typically obliged to practise, both during class and at home, in order to save face. In the case of online learning, this pressure is often absent, hence why the development of a student’s problem- solving skills is in part reliant upon said student’s drive to engage with the material. As such, the efficacy of online learning can never be guaranteed with the same certainty as classroom-based teaching methods.

On the other hand, there may be benefits to a mathematical problem-solving curriculum delivered online, particularly when it comes to the notion of ‘reviewing’. As with ‘active engagement’, there is a clear consensus among the various approaches to problem-solving that taking the time to review one’s work after the fact is a valuable exercise. Mason et al. (2010) state that ‘without reflection, practice can wash over you, leaving no permanent marks’, but by reflecting on key ideas/strategies employed during the problem-solving attempt, implications of the arguments presented and how the solution might be improved, one ensures that the effort one has gone to in practising solving problems is worthwhile, since it allows the lessons learnt to sink in. Whilst the ‘rapid question/answer’ dynamic fostered by traditional mathematics classrooms often prevents students from carrying out this all-important exercise (Mason et al., 2010), technology-enhanced learning implementing asynchronous delivery affords them the opportunity to take their time when looking back at what they have accomplished and what they can learn from it.

Ironically, despite its association with the purest of the sciences, mathematical problem-solving is not a discipline in which students’ accomplishments are easily assessed, hence the lack of meaningful quantitative data to support an argument either in favour of or against online learning. Of course, web-based media merely constitute tools whose success in supporting the development of mathematical problem-solving skills is dependent on how they are employed by the user and are by no means ineffective in supporting mathematics education when used in conjunction with classroom-based methods, but qualitative evidence favouring the conventional approach to learning how to solve problems coupled with my own experience and the experiences of those around me (figuratively speaking, of course) has led me to the conclusion that conducting a mathematical problem-solving curriculum wholly online is not an adequate substitute for traditional classroom- based learning.

References:

1. Smith, G.G. and Ferguson, D. (2005) *Student attrition in mathematics e-learning*, *Australasian Journal of Educational Technology*, 21(3). Available at: <https://doi.org/10.14742/ajet.1323>(Accessed 27 March 2021)
2. Mason, J. Burton, L. Stacey, K. (2010) *Thinking Mathematically*. (2nd edition). Pearson.

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What impact do you think online learning has on the way students learn to solve mathematical problems?

A student's success in solving mathematical problems is based on three fundamental components:

* having appropriate mathematical knowledge;
* an ability to deconstruct a problem into parts that can be approached by the relevant mathematical knowledge;
* and an understanding of how to approach these deconstructed parts: the methods to approach the problem and how best to navigate difficulties students encounter.

The basis for these skills can be attributed to various points across students' mathematical education, and as such this essay will explore the impact of online learning across different levels of education, and also the quality and style of online education they experience.

This essay will assess the impact online learning has across the three components, considering the range of different experiences students might have in these areas, to analyse the impact of online learning to problem solving learning across the education system as a whole.

Having appropriate mathematical knowledge

In this essay, ‘appropriate mathematical knowledge' refers to mathematics that is suitable to the age and capability of the student, and relevant to the problems that will be posed for them to solve. The teaching of mathematical content is critical to students' learning to problem solve, as they cannot begin to tackle problems that they don't have sufficient tools for.

This means that a significant impact of online learning on the way students learn to solve problems is the way in which mathematical content that underpins such problems is taught. Across all ages, moving mathematics teaching online caused significant change to the way in which students learn.

Learning of mathematical content has seen a sharp rise in independent work - removing the in-person classroom environment is limiting to the amount of collaboration or supervised learning students can engage in (Dumford & Miller, 2018). Whether in the classroom or a lecture theatre, a principal element of learning comes through more personalised teaching - either from asking teachers questions specific to a problem they are stuck on, or leaning over to a classmate to query how to interpret the move from one line of working to another - smaller questions such as these feed into independent learning, with students having to rely on themselves, or independent research into resources and the internet. For students more reliant on taught content, this could have significant detriment to their learning to problem solve, and this could be further exacerbated for students with specific learning needs and younger students who have difficulty with attentiveness.

However, for students already in more independent learning environments, such as university students, one could argue that independent learning is in fact easier now than ever, and education more accessible for students with differing learning styles. With recorded lectures, students can review content, pause and replay sections according to their own needs, and enjoy a more personalised experience. This could be beneficial to their understanding of content overall, which makes them better equipped to tackle problems and thus benefits their learning to problem solve.

Of course, the success of more independent learning is critically dependent on students' learning preferences, access to technology, and the way in which their online learning is delivered, but the knowledge that students acquire is crucial to their ability to problem solve, core to the ‘entry phase of the rubric process taught in MA3E7.

Deconstructing a problem into parts

Considering now the ability for students to deconstruct a problem into parts, the essay means to specify the competence and understanding to relate the question posed into relevant mathematical parts, and grasp what mathematics is necessary to ‘attack' the problem.

One element of learning that is critical to curating the necessary skills for this aspect of the problem solving approach is external advice on students' thought processes as they consider problems, and guidance that helps reshape the way in which a student dissects a problem into ‘approachable’ mathematics.

The move to online learning puts new restrictions on mathematical writing and expression, especially for students without access to technology such as a graphics tablet, or computer programs that provide tools for students to easily express their workings (Galligan, Hobohm, & Loch, 2012). If educators are unable to see how a student has deconstructed a problem, issues in the way that the student learns to problem solve may grow with more complex problems.

Another detriment is that students may not be working in real time with others. The concept of an ‘internal enemy' is first experienced by students as an ‘external enemy' - in their classmates, their teachers - working independently and remotely removes this learning device that allows students to start recognising their own mistakes and inefficient or irrational approaches to a problem.

Approaching the deconstructed problem

Contrary to the detriments above, however, online learning does pose opportunities for beneficial impact on students' learning to problem solve, particularly with respect to their understanding of how best to approach the deconstructed parts and in navigating difficulties they encounter.

Methods to approach the problem

Often in mathematics, proof of understanding is derived by obtaining the correct solution, in the classroom and examinations, where educators can monitor students and restrict the use of technology, the internet and calculators.

A move to online learning has been fraught with concerns of cheating and unfair advantage. This could be a detriment, but it could also be a needed detriment to change the way educators, and thus students, quantify understanding. Embracing the fact that students could easily achieve solutions with the aid of technology, online learning is an opportunity to shift from solution-based focus to proof-based focus, encouraging students to write mathematics, which vastly improves their learning (Bossé & Faulconer, 2008), and to prioritise rigour and approach over calculations and outputs. The impact of this on students is a heightened importance on their approach to a problem, hugely benefitting their learning to solve mathematical problems.

A barrier to this is that many online submission systems utilised by educators only narrow mathematics down to a problem's final output without reward for method, especially for students at lower stages of education. While proof-based working is already core to most university-level mathematics, younger students may reap less of the benefits of online learning to how they learn to solve mathematical problems.

Navigating difficulties

Navigating difficulties is the other central foundation in learning to problem solve, and online learning provides both benefits and disadvantages to students' education. While one could argue that the increased independence of students' learning may drive them to persist with difficulties, the increased access to technology allows for students to reach out to their classmates or to the internet for assistance far earlier than a classroom environment would allow, reducing their ability to navigate problem solving difficulties by their own intuition and resolve.

However, an argument can also be made that the very detriment to their problem solving learning mentioned prior - the restriction on mathematical expression - might act as a benefit to the way in which students learn to resolve being ‘stuck' when problem solving. Especially in online classes, the easiest method of communicating mathematics (across even more limited technologies) is verbally; in talking through problems with one another, students are afforded more opportunity to check their own understanding and prior working (Webb, 1991), which is a key concept in the problem solving approach of MA3E7.

Altogether, the impact online learning has on the way in which students learn to problem solve is significant, however this essay does not find that this impact is necessarily to the detriment of their resulting problem solving abilities. The extent of the impact can vary depending on the student's level of mathematics, and the technology they are afforded for online learning. This essay concludes that for younger students there are far less benefits. However, while online learning may be consequential to the development of older students' problem solving, those students may be no less successful problem solvers than those before, but perhaps having differing areas of strength.

1299 words

Bibliography

Bossé, M. J., & Faulconer, J. (2008). Learning and Assessing Mathematics through Reading and Writing. School Science and Mathematics, 108(1), 8-19.

Dumford, A. D., & Miller, A. L. (2018). Online learning in higher education: exploring advantages and disadvantages for engagement. Journal of Computing in Higher Education, 30(3), 452-465.

Galligan, L., Hobohm, C., & Loch, B. (2012). Tablet technology to facilitate improved interaction and communication with students studying mathematics at a distance. Journal of Computers in Mathematics and Science Teaching, 31(4), 363-385.

Webb, N. (1991). Task-Related Verbal Interaction and Mathematics Learning in Small Groups. Journal for Research in Mathematics Education, 22(5), 366-389.

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What impact do you think online learning has on the way students learn to solve mathematical problems?

Unsurprisingly, since the start of the COVID-19 pandemic, technology has become an even more significant part of our lives. The world has had to make the switch to online learning earlier than expected, having a substantial impact on the everyday lives of students, and the repercussions from this unforeseen switch can be considered both positive and negative. This essay focusses on the impact of online learning in solving mathematical problems, delving into theoretical and academic discussion around the efficiency of teaching online, as the class sizes can be infinitely large with the same teaching quality. While also discussing difficulties in maintaining academic integrity; this is especially important when learning to solve mathematical problems [1]. This essay will also look at further points to analyse and debate both sides of the argument before coming to a solid conclusion.

Solving mathematical problems requires an understanding of not only the problem but also the objective, and notations [8], all of which many students already struggle with, irrespective of their intelligence.

Moreover, problem solving is such that all topics prior to the topic at hand are needed to approach the question. Hence, if one misses a topic, it is much harder to understand future ideas, especially without an understanding of basic math. With online learning this becomes increasingly difficult, as it requires more motivation and self-discipline than if it were in a classroom. Furthermore, a classroom has multiple teachers/instructors who can record the students’ achievements and ensure students complete their work. Whereas online learning necessitates students tracking their own deadlines and progress [3].

Certainly, online learning poses difficulty in other areas such as communication and connectivity; issues with Wi-Fi, laptops malfunctioning and the inability to communicate effectively. These present major interferences in mathematical problem solving. Problem solving requires interacting with others, having discussions to analyse the problem, and using creative thinking to solve them. These skills are much harder to acquire when working virtually without the ability to practice with others. Consequently, a student’s ability to learn the necessary techniques to approach a problem in an innovative and analytical method are hindered.

One major concern of online teaching is that teachers may neglect proper teaching methods by rushing over the content and not providing enough support for the students, especially those who struggle more with problem solving/analytical skills. [6] Many students report falling behind and being reluctant to engage with more challenging ideas that usually take more time to grasp. This may lead to students who previously had a positive or growth mindset, begin to develop a set mindset [9]. In such a mindset, ‘people believe their basic qualities, like their intelligence or talent, are simply fixed traits. They spend their time documenting their

intelligence or talent instead of developing them’ [11].

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Description automatically generatedHowever, it is worth noting that that further studies have indeed found opposing results. A study conducted in The Hashemite University (Jordan) - which focusses on our topic of discussion on seventh grade students - calculated the arithmetic means and standard deviations of the performance of the participating students [2]. Figure 1 below shows these results.

Figure 1: Arithmetic means and standards deviations of the study sample’s performance related to mathematical problem-solving skills. [2]

The difference in the arithmetic mean of the scores of each skill between the control group (classroom study) and the experimental group (online learning) is clearly identifiable. It is evident that students taught via mobile learning have averaged with higher skill levels, due to technology allowing for screens to display an explanation of the work that was shown, along with videos and images to aid the students. The study concluded that ‘students learn when words and their accompanied images are adjoining on the screen, rather than when they are presented separately’ (Cynthia, 2010). This confirmed that using online learning improved attainment and helped students to visualise and absorb information via visually appealing screens which increased students’ attention and engagement during lessons.

We shall now look at the benefits of using technology to teach mathematics and problem solving. Firstly, online learning allows students to have more opportunities to grasp and cooperate with mathematical concepts [5]. Hence, students can further investigate concepts and digital tools which can aid their learning in how to approach and solve mathematical problems. Secondly, teachers can create interactive visualisations and explorations to present mathematical problems, which can allow for personalisation for each student to cater to their needs. Students can be provided with online resources to support them further. Such resources allow the student to view them at their own pace and in their own time. This means that parents are able to see the content of the lessons and understand the concepts, hence can help their children from home with solving problems and revising the information. [7]

Additionally, Khan Academy (An American non-profit educational organisation, with the goal of creating a set of online tools that help educate students. The organisation produces short lessons in the form of videos. Its website also includes supplementary practice exercises and materials for educators [10]) is an example of teaching mathematical problem solving online and giving viewers a personalised learning experience by creating quizzes for students to test topic proficiency [7]. There has always been a debate about the optimal method in teaching problem solving in mathematics and many theories on how learning to solve mathematics is a complex task, one which is not so easy to teach. This conveys that both online and classroom approaches are not individually sufficient to maximise problem solving abilities in students.

A logical solution would be to combine the benefits of online learning and classroom teaching to help students learn to solve mathematical problems. I believe this would be the most effective method. This may be reiterated by the case study presented in the book written by James P. Howard II [4], where we see that students who had both online homework and paper-pencil homework attained substantially higher scores on the final exam than students with either single one [13]. Furthermore, by dividing the class into an experimental and control group, we were able to conclude that students in the experimental (online) group scored an average of 4% higher than the control group (pen and paper). It has also been concluded that students spend more time on homework and complete more homework when it is online [12].

All things considered, the best approach to teaching mathematical problem solving is one which incorporates both online learning and classroom teaching. The benefits of each strategy are notable, and by conducting further studies, we can learn more about the effect of online learning on learning to solve mathematical problems. Learning to solve mathematical problems is a skill, and it is one that is supported by technology as it allows students to expand their knowledge in various ways. This, hand in hand with communication and discussion, will be the optimal way to teach students how to solve mathematical problems, and may be the beginning of a new phase of education - one led by new technologies and innovations.

References:

1. - <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7306967/>
2. - <https://online-journals.org/index.php/i-jim/article/viewFile/8713/5064>
3. - <https://www.educationworld.in/impact-of-online-learning-on-school-education/>
4. − Teaching and Learning Mathematics Online (James P. Howard II) 2020
5. - [https://www.texthelp.com/en-us/company/education-blog/march-2018/what-are-the-benefits-of-](https://www.texthelp.com/en-us/company/education-blog/march-2018/what-are-the-benefits-of-using-technology-for-math/) [using-technology-for-math/](https://www.texthelp.com/en-us/company/education-blog/march-2018/what-are-the-benefits-of-using-technology-for-math/)

[6] - <https://link.springer.com/content/pdf/10.1007/s13394-020-00339-6.pdf>

1. - [https://www.texthelp.com/en-gb/company/education-blog/march-2018/what-are-the-benefits-of-](https://www.texthelp.com/en-gb/company/education-blog/march-2018/what-are-the-benefits-of-using-technology-for-math/) [using-technology-for-math/](https://www.texthelp.com/en-gb/company/education-blog/march-2018/what-are-the-benefits-of-using-technology-for-math/)
2. − Solving Mathematical Problems (Book), Terrence Tao (2006)
3. − Self-theories. Their Role in Motivation, Personality and Development, Carol S. Dweck (2000)
4. - <https://www.khanacademy.org/>
5. − Mindset: The New Psychology of Success (Book), Carol Dweck (2006)
6. - Gage, Pizer, & Roth (2003)
7. - Hirsch and Weibel (2003)

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