Encouragement Of Technology In Mathematics Education

Introduction

EdTech is the “practice of using technology to support teaching and the effective day-to-day management of education institutions” (Department for Education, 2019, p. 5). UK EdTech companies received c. £91 million worth of investments in 2018 (Halmari, et al., 2018). This level of support is unprecedented given that it equates to a 140% increase from investments in 2016. EdTech is following technology trends worldwide by relentlessly innovating and disrupting traditional teaching methods at every academic level. However, Ofsted (2012) highlights that although these resources can promote conceptual understanding, they are not being used effectively by many schools.

This raises the question that, given the significant growth and abundant support and innovation in the EdTech sector, why is this not reflected in Mathematics lessons? Furthermore, what benefits and drawbacks are likely to occur if EdTech was encouraged?

Benefits of EdTech

Improved Exam Results

The primary argument for the introduction of technology into education is that it should improve student attainment. If integrating technology into Mathematics education doesn’t improve grades or engagement, then the investment may be deemed worthless.

MathsFlip is an educational technology that allows teachers to access resources relevant to the current topics being taught. These recourses are made accessible to students to be completed at home, then similar activities can be done in class to further support their learning. The trial of MathsFlip was performed across 24 KS2 year groups from 2014-2015 in the West Midlands and was investigated by the Education Endowment Foundation (2018). The results showed that after using the resource for new Mathematics topics, students made progress equivalent to one month compared to the control group. Although small, this positive result set the tested students ahead of peers, suggesting that technology can benefit students academically.

Riconscente (2013) researched the use of tablets in education by testing 122 fourth-grade US students. Motion Math is an iPad-based fractions application used to help students improve their understanding of the relationship between fractions and percentages. Riconscente (2013) found that playing Motion Math for 20 minutes per day for one school week resulted in improved fraction test scores by on average 15%. Against the control group, this is highly significant. Riconscente (2013) also found that the student’s confidence and enjoyment of fractions were enhanced by an average of 10%. This further supports the argument for introducing technology to benefit Maths education.

Kelly et al. (2013) studied the use of the Mathematical assessment tool, ASSISTments, by 63 students. The students were either assigned to a traditional homework condition without feedback or a web-based homework condition with correctness feedback and the option to try

again. The students were given a pre-test and a lesson on negative exponents and then completed the homework the same evening. Kelly et al. (2013) found that students learned more in the web-based condition, with an effect size of 0.56. This suggests that even without delivering the lessons in a technology-based manner, students can benefit from using technology in their education. Using a web-based homework system can provide students with immediate feedback which can encourage them to remain engaged by practicing questions to improve understanding. This also reduces the marking workload for the teachers.

Workload Reduction for Teachers

One of the main causes of stress-related illness in a teaching career is the workload. Increasingly, marking and creating lesson plans continues into evenings and at weekends. In their ‘State of Technology in 2019/20’ report, Promethean (2019) state that “81.2% of teachers believe workload is contributing to high levels of stress in schools” (Workload and Wellbeing). They also state that “over half of respondents (52%) agree workload or long hours are the biggest threat to retention” (Workload and Wellbeing). This suggests teachers are overworked which encourages absences or resignations. Moreover, research by Holden (2018) suggests that a teacher’s first year of practicing costs a school £12,000 and subsequent years only £400. These findings confirm the alarming reality that the effects of an intense workload can cost schools a considerable amount of money.

The Department for Education (DforE) (2019) has identified five opportunities where education activities should be focused. Two of these concern teacher workload: “Administration processes – reducing the burden of ‘non-teaching tasks”, and “Assessment processes – making assessment more effective and efficient” (p. 32). The findings of Kelly et al. (2013) are prime examples of how technology can help meet these opportunities. These systems reduce the marking workload, as well as the administrative tasks of uploading scores into spreadsheets and tracking progress. In fact, these systems can be more informative and diagnostic than marking by hand as they can track attainment and automatically highlight any issues or strengths for individuals and classes.

Incorporating technology into lesson plans, homework and assessments has traditionally been considered as a further contribution to workloads, rather than easing them. Although it requires initial training and a revamp of lesson plans, technology has been shown to reduce workloads. Jackson and Makarin (2018) studied Maths teachers from grades 6 to 9 in three Virginia school districts. The technology used was ‘Mathalicious’, who create lessons that look at the Maths and logic behind highly applicable real-world issues. For example, their lesson ‘Loan Ranger’ investigates the use of credit cards including interest rates, monthly compounds, and payback options (“Loan Ranger: A Lesson by Mathalicious”). The teachers were separated into full subscription (access to lessons and support), license-only subscription (access to lessons) and control groups. The study gave the following results based on the Mathematics section of the Virginia Standards of Learning assessment for each district. Providing the teachers with a full subscription improved student Mathematics achievement by 0.09? compared to the control group. Providing the teachers with the license-only subscription improved student Mathematics achievement by 0.06? compared to the control group. Although a possible reason for this is that students received a more engaging education which stimulated greater understanding, Jackson and Makarin (2018) give a teacher-motivated explanation. The results were significantly enhanced for weaker teachers, prompting the idea that “as teachers substituted the lessons for

their own lesson planning efforts, they were able to spend more time on other tasks such as providing one-on-one time with students" (p. 251). This study supports the notion that technology can ease teachers' workload, which can in turn improve student's education.

Drawbacks of EdTech

Lowered Exam Results

Pane, Mccaffrey, Slaughter, Steele and Ikemoto (2010) investigated the academic impact of the Cognitive Tutor Geometry (CTG) curriculum over three years in eight secondary schools in Baltimore. CTG is a technology-based course that aims to encourage understanding of geometric concepts and abstract and spatial reasoning skills. The following statements were concluded after teachers applied CTG for a year: "Teachers found the group tasks particularly challenging to implement effectively. …Because the curriculum was self-paced, students typically did not complete them at the same rate that material was covered in class" (p. 26). Pane et al. (2010) found the curriculum had a statistically significant negative effect on student achievement. They believed that after a year of using CTG, student achievement was about 0.19 standard deviation units less than if they had used the standard curriculum. In other words, achieving a median score after a year of the CTG curriculum would result in the student being at the 43rd percentile of the standard curriculum distribution.

Higgins (2010) investigated the outcome of using interactive whiteboards in 80 primary schools in England. The study exclusively looked at Literacy and Mathematics classes over a three-year period. This study showed little improvement in test scores. In 2002, the interactive whiteboard school's official test scores were five points higher than the national average in Literacy and Mathematics. In 2003, Higgins (2010) found that there were statistically significant improvements in the mean raw test scores in the interactive whiteboard schools compared to the control schools. In 2004, the final year of the experiment, there was no significant difference between the test group and the control group in terms of exam scores. Teacher's own assessments correspond to this, with insignificant score differences between groups, and a 0.04 effect size for Mathematics. These inconsistent results give unconvincing support for the argument to introduce technology based on an improvement in attainment. Higgins (2010) suggests that the early promising results could be due to the Hawthorne effect, which is "when there is a change in the subject's normal behaviour, attributed to the knowledge that their behaviour is being watched or studied" (Oswald, Sherratt, & Smith, 2014, p. 53). Higgins (2010) proposes that the lack of attainment in test results in the interactive whiteboards group indicates an absence of direct effect. Furthermore, 81% of the teachers in the study believed that their workload increased after the whiteboards were introduced. This contradicts previous studies which suggest that technology can help to ease workload. Although one third of the teachers thought that this would only be a temporary increase, the initial increase in workload, and therefore stress, is a strong argument against implementing technology.

Loss of Fundamental Skills

Another factor which causes resistance in implementing EdTech is that students may lose their intuition and perseverance in Mathematics when using technology. Lenz (2010) tested a web-based homework system in a first-year mathematics course. The course contained many topics, and students either completed homework online, by paper, or a combination of the two. Lenz

(2010) found the web-based group were more likely to complete the homework and attain higher homework grades than the paper group. However, the study found no significant difference between the groups in their final exam grades. This suggests that web-based homework may develop Mathematics knowledge short term, but students may miss out on skills developed from traditional paper-based homework.

For example, a piece of homework may contain a complex integration question. The student starts the iterative process of writing steps, obtaining a solution and checking for mistakes until satisfied their final solution is feasible. This is marked in-depth by their teacher who highlights mistakes in layout, calculations and understanding. A student may reach the correct final solution, but incorrectly evaluate cos(0)+cos()=0+0=0, instead of cos(0)+cos()=1+(-1)=0. The teacher identifies this error and ensures the student learns from their mistake. Homework of this format can effectively develop knowledge. Another student completes the homework online. They reach and input the same final solution, and the software shows the correct method or simply moves on. Their method isn't marked and the student fails to correct their understanding of the cosine function, specifically cos(0)+cos(). If this continues in Maths homework, the student may not develop essential knowledge required in exams and further study. Regarding this study, web-based homework may have been more engaging, promoting an uptake incompletions. This new, interactive nature may lead to an increase in knowledge. However, if the students cannot check their method or understanding, their success on the exam is limited. This highlights how Edtech must be used alongside traditional teaching and testing pedagogies, rather than replacing them.

Conclusion

The debate about introducing technology into Mathematics education is highly topical and important. There is a vast choice of services currently available, and huge demand for further innovation. This has been publicly supported by Government-run bodies, such as the DforE (2019) and Ofsted (2012). However, the decision cannot be taken lightly given the possible negative outcomes. Lenz (2010) suggested that a web-based homework didn't assist students' knowledge enough to support their Mathematics exams. In fact, has been suggested by Higgins (2010) and Pane et al. (2010) that EdTech can even reduce student Mathematics attainment.

In contrast to this, researchers including the Education Endowment Foundation (2018), Riconscente (2013) and Kelly et al. (2013) have concluded that EdTech benefits the Mathematics achievement of students. EdTech's ability to reduce teacher workload is a significant benefit in terms of reaching the DforE's given opportunities (2019). If EdTech eases teacher workload, the cost of maybe worthwhile given the previously highlighted expense of teacher turnover.

The EdTech sector, like technology in general, will continue to grow and provide innovative opportunities. Schools must evaluate the benefits and drawbacks of introducing EdTech into Mathematics education. However, they must consider that technology should be used to compliment, rather than replace pedagogies. A constant challenge for schools is to present Maths in a relevant, stimulating way to engage students enough that they enjoy the subject. Resisting these technological opportunities could exacerbate this challenge. Perhaps integrating the modern world into Mathematics lessons could be the next step towards improved student engagement in Mathematics.

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