SOWISO

E-learning and The Maths Problem

How to leverage digital solutions to address specific teacher and student problems

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1. The Maths Problem

Mathematics education in Higher Education is in trouble. Several high profile institutions have highlighted how students' mathematical ability is declining overall and that students, particularly those in tangential academic subjects such as Engineering, Chemistry or Biology, are ill-prepared to study maths. This has an impact on their ability to succeed at their chosen subject. This effect has been noted in the UK[1], Australia[2], Canada[3] and Hong Kong[4] and across fields as diverse as Biology[5], Engineering[6], Nursing, Bioscience and Business[7].

The Maths Problem has been blamed on a variety of factors from poor maths education at secondary school level[8,9], differing abilities and educational levels within groups of students[10], the inflexibility of traditional teaching processes[11] and a general lack of core skills[12].

Some universities have pioneered the use of short, intensive prep courses such as Flying Start. Such courses commence before the start of official lectures and aim at ensuring students begin the course with similar abilities and understanding of mathematical concepts. However the usefulness of such prep courses is limited in contemporary HE. In order to provide results, class sizes must be kept small (11 students only in the case of Flying Start) and evidence has shown that performance drops off in second year while prep courses are only available for first year students - any gains from courses like these are short lived[13].

Other approaches to the issue of maths learning for non-maths students have included creating more attractive visual learning materials, streaming, drop-in support or online support systems.

and using computer aided assessment to increase the amount of feedback between students and professors[8,14].

One significant front-runner has emerged however. The use of online learning platforms for the purposes of teaching mathematics is supported by many academics.

The use of online learning platforms for education is successful in terms of learning outcomes, allowing teachers to deliver stronger, better supported courses to their students.

We believe the best way to assist HE institutions with delivering mathematics learning is through online learning platforms founded on firm pedagogical principles such as student centred learning and flipping the classroom.

This paper considers some key teaching and learning issues that exist in mathematics classrooms around the world and how online maths learning platforms can help manage these issues. In effect it is an overview of the main things we've learned from our last ten years in digital education, which has only served to reinforce our conviction that an interactive, online learning platform is the best way to assist Higher Education institutions in teaching maths, particularly to non-mathematics students.

2. Digital Education and Online Learning Platforms

An increasingly popular way of leveraging understanding for crucial skills in an effective and fiscally conservative manner involves using technology to assist teaching. Digital education is increasingly popular across most sectors of education, particularly when partnered with newer pedagogical approaches such as blended learning or flipping the classroom. This partnership is particularly helpful in the context of larger classrooms, fewer teaching staff and diverse and sometimes unmotivated student bodies.

Although a future of entirely digital learning is within sight, it is not yet an actionable prospect for many educational institutions. Instead, many HE institutions are focusing on a blended learning approach which combines face-to-face teaching with digital materials and mechanisms for learning. One definition of blended learning is what occurs when,

'learning takes place through several channels such as, combining Internet and digital media with the procedures establishing the classroom with physical co-presence of teacher and students[15]*'.*

There are several advantages to such approach, including: allowing teaching staff more contact time with students[16]; providing options for students with different working patterns and learning styles[17] and lower institutional costs[18].

Blended learning is frequently combined with another approach dubbed the 'flipped classroom' approach or 'flipping the classroom'.

In the flipped classroom approach, 'students review lecture materials previous to master class[es] and then attend theoretical classes to develop learning activities with an instructor[19]'. Students focus on problem solving, interactive activities or discussing issues with a professor during face-to-face contact times[20]. This approach allows for more interaction between students and professors and challenges the 'predominantly lecturer-focused approach [which is] characterized by student passivity[21]'. Learning involves a dialogue between teachers and students rather than a monologue.

There is also an increasing understanding in HE institutions that mechanisms of learning need to 'meet students halfway[23]'. Today's students are 'digital natives' used to interacting through digital means. Distraction and an inability to concentrate on traditional forms of content are posited as problems for modern students. Modern students have different needs and expectations of education and there is a 'rising interest among academics in engaging and empowering students as agents of their own learning[8]'.

However most agree that for mathematics learning to be effective it needs to go beyond a mimicry of traditional lecture style and use interactivity and personalized feedback to make education helpful and relevant.

Online learning platforms have been particularly effective within the field of mathematics. As maths is a subject which requires extensive practice, regular assessment and endless variations on the same question, it is strongly suited for a digital platform.

These platforms go beyond using the standard lecture format to teach and instead teach through practice. Students can practice mathematical concepts progressively based on their current ability. Platforms provide endlessly randomized exercises, allowing students to practice the same material repeatedly with very little chance of encountering the same sum twice. Students are provided with personalized feedback, allowing them greater insight into their strengths and weaknesses in mathematics.
The platform can be used by students alone, as a platform for homework or practice exercise, but can also become a central part of teacher-led university courses. Implementing principles of the flipped classroom and blended learning, professors can use content as a digital and interactive textbook. Such platforms can also be used for digital assessments, removing some of the burden of exam marking and progress monitoring.

While such online platforms are not a single or universal solution to The Maths Problem, they provide a way of addressing the issue which is both effective and financially responsible. Online learning platforms provide solutions to various sub-problems that teachers and students struggle with. The following section will outline the most common problems that students and teachers encounter in mathematics learning, along with how an online platform can provide a solution to this.

3. 4 common problems in maths education that EdTech solutions solve.

For an online platform to be helpful for its users - both teachers and students - it needs to address the actual problems they experience. Solving these problems up to this point has been tricky but online learning platforms such as SOWISO offer an opportunity to address problems differently. Although no solution can abolish a problem completely, digital technology can be harnessed to help.

The following section describes 4 common problems experienced by teachers and students in mathematics courses, particularly foundation maths classes, and demonstrates how online learning platforms can address these.

1. Professors don't have enough time to prepare lessons and complete teaching tasks

Professors and teaching staff are often overburdened with the work associated with teaching tasks. This becomes obvious as class sizes increase and funding for additional staff, like teaching assistants, decreases. Grading takes up considerable time often with the result that professors set fewer assessments, to avoid generating large amounts of grading. Teaching staff often need to spend individual time with students to assist with assignments or explaining complex concepts. Teaching staff are required to create assessment materials, either regularly or once per term. This exercise takes time and finding new material can be taxing.

Successful strategy: Make homework and some assessment fully digital.

Interactive online learning platforms can provide a completely new way for teachers to set and grade homework. Regular homework assignments or more significant assessments can be set through an online platform.

Creating assessment materials is easy and can provide endless variations of similar questions, meaning teachers no longer need to spend extensive time on preparing assessment materials.

Online platforms can automatically check and grade diagnostic, formative and summative randomized tests[23], limiting or completely removing the process of marking and grading assignments.

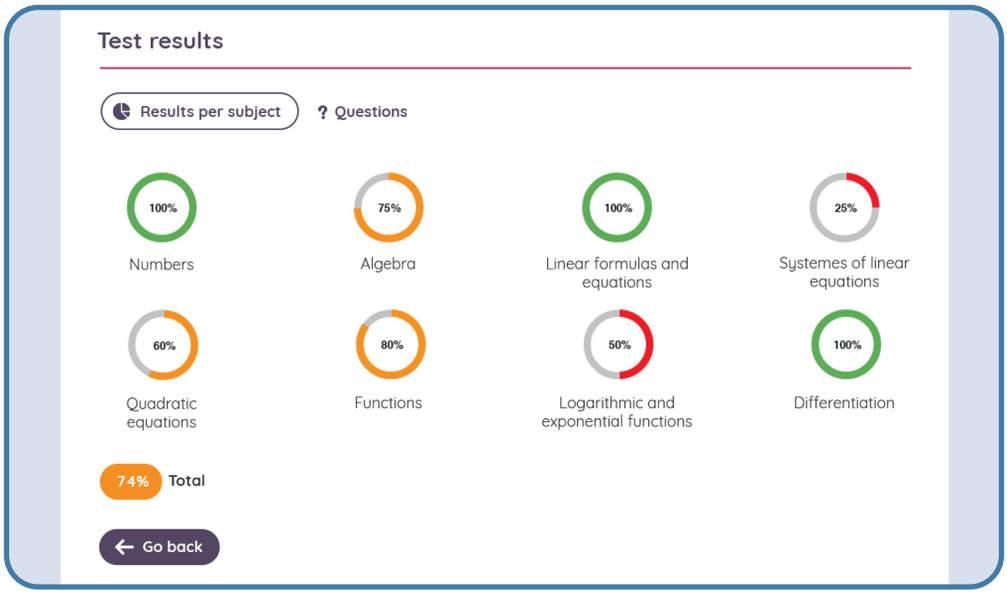

Fig. 1 - Screenshot of the SOWISO test interface

Feedback integrated into the platform allows students to begin to solve their learning problems and deficiencies in knowledge themselves, without relying on a teacher. This can be backed up by further practice material. This limits the amount of face-to-face instruction that is required from teachers when students are struggling with an issue.

These tools remove or limit some of the tasks that monopolize teachers' time, allowing them to focus their energies on making contact teaching time constructive, complex and enjoyable. This system also ensures that teachers do not spend time addressing learning issues that students can solve themselves, reserving their energies for complicated or intractable problems, or struggling students.

2. It's not easy to identify which students are struggling

With increasing class sizes, as well as a diversity of student experiences and abilities, it can be difficult for professors to identify which students are struggling. Regular testing is helpful in this regard, but not always feasible. Analysis of test results creates additional work for professors, and regular and sustained monitoring is an additional and complex task for teachers. Struggling students can get missed or only draw attention when they are already failing the course.

Successful strategy: Implement the use of learning analytics to identify weaknesses in content and individual students.

Fig. 2 - Screenshot of the SOWISO Analytics interface

Regular testing is often a part of maths-based courses, whether digital or analogue. However, regular testing is not helpful unless the generated results can be transformed into something useful for professors and teaching staff. Learning analytics, as part of an online personalized learning platform, allow teachers to proactively identify issues[24], improve their curriculum[25] by focusing on problematic topics or rearrange aspects of the course to facilitate learning.

Learning analytics integrated into a personalized learning platform provides detailed analysis for subsections, topics or even individual exercises. Teachers can get a quick overview of how their students are progressing as well as focusing on a particular student to identify issues. The combination of general and specific data allows teachers to make up-to-the-minute and accurate decisions about the course and their students.

3. Students are discouraged or intimidated by regular practice, reducing their interest and confidence overall

Students who do not come from a mathematics background can be discouraged by regular practice, particularly while they are learning complicated principles. Poor initial test results can be intimidating or undermine students' confidence rather than encourage them to practice and interact with the learning material. A lack of helpful, or any, feedback means students feel disempowered and confused, continuing the cycle of avoiding regular practice.

Successful strategy: Use targeted feedback and randomization to encourage multiple attempts and mastery-based learning.

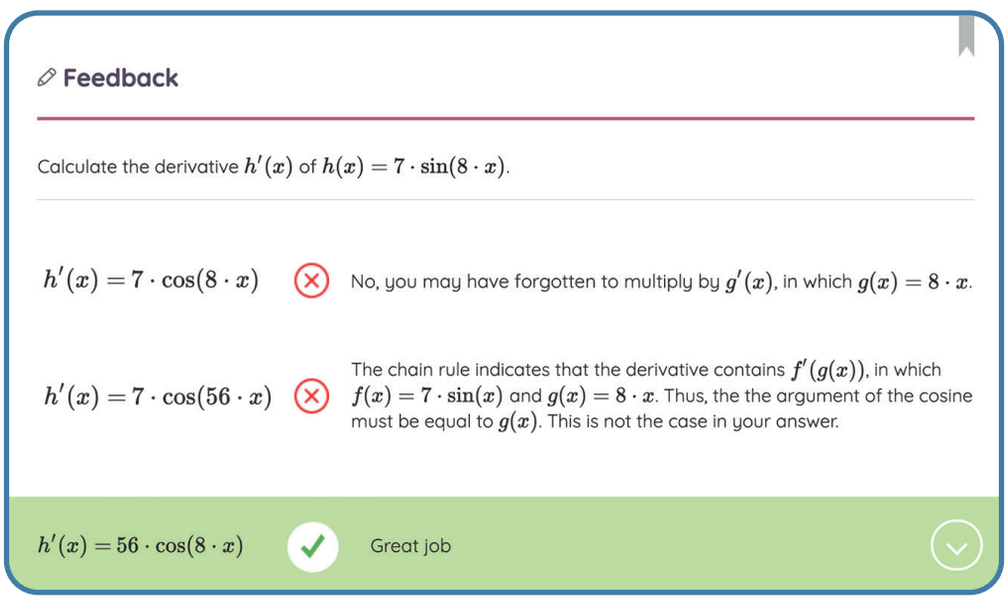

Fig. 3 - Screenshot of an exercise in SOWISO with targetted feedback

Targeted feedback gives students detailed information on how their wrong answer is problematic. Rather than simply informing a student that their response is incorrect, targeted feedback directs the student to where the problem lies. Furthermore, targeted feedback is responsive, and will give additional hints based on the changes made. Once a question has been attempted a certain number of times, the system will explain the concept, following through the working of the mathematics problem from beginning to end.

Combining targeted feedback with randomization and endless variables means that students can continue to practice the same problem with no chance of repeating the question. This pushes students to work through questions continually, guided by responsive feedback.

These features are often combined with a mastery-based approach which means that when students undertake practice work or homework, the highest score on any attempt at an individual question counts. This encourages students to make multiple attempts at a question, improving their understanding and their scores each time. This motivates students as they are not punished for making mistakes, provided they find the correct answer at some point. This approach also promotes the mindset of ongoing practice and does not penalise taking risks when answering questions.

4. Students have trouble keeping up with the progress of a maths course

Foundational mathematics courses for non-mathematicians move fast, with large amounts of content contained in modules of 6-8 weeks. There is a significant risk that students will fall behind the progression, risking drop out or failure. Missing an occasional class is an expected inconvenience. However fast-moving classes, involving students who may struggle with both motivation and understanding, can quickly derail student progress and make it difficult to get 'back on track'. Moreover, if students miss classes it may be impossible to recover.

Successful strategy: A combination of regular practice, formative testing and digitized content keeps students focused and up-to-date.

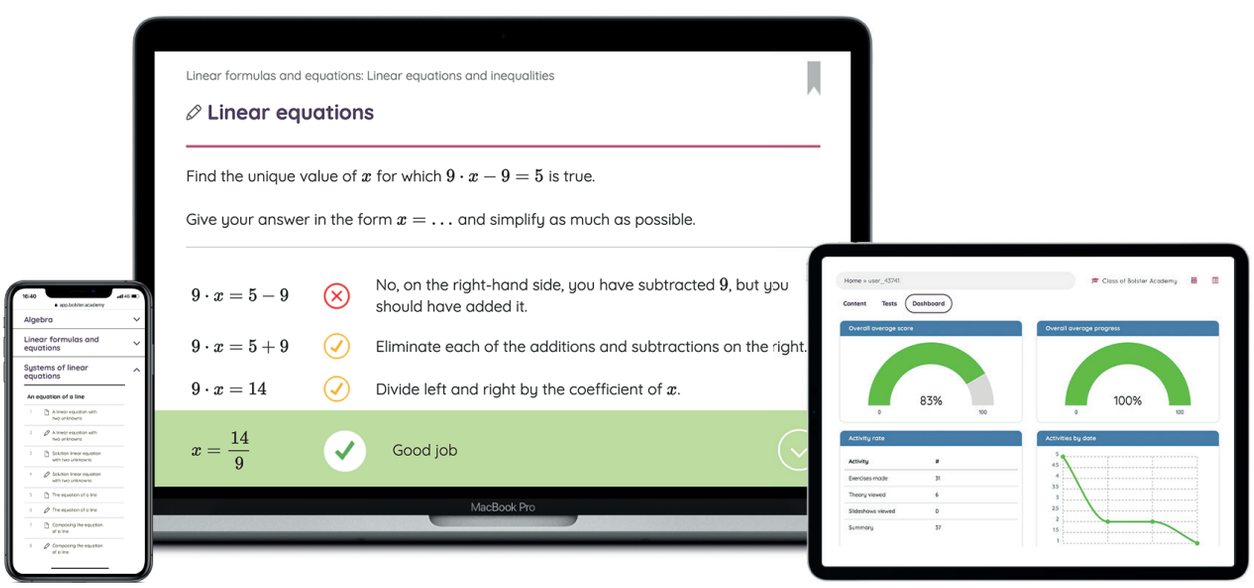

Fig. 4 - Various SOWISO features (responsive)

Several features of online learning platforms in unison assist students in keeping up with course content. Regular formative testing involves tests whose feedback does not contribute to a final grade[26,27]. This lowers barriers to participation and allows students to use tests as a short term measure of their progress, while avoiding the stress of marked assessments.

Using online learning platforms, such assessments can easily be instituted with very little additional work for teaching staff.

When combined with regular practice through the platform, students can engage with material continually, including outside of classroom time, improving their outcomes. Some students have noted the benefits of learning a particular subject each week and having the possibility to check their progress through testing.

In addition to this, online learning platforms record all the material required for a course. Providing a digital coursebook, along with regular assessment which delineate expected progress, means students are less likely to fall behind if they miss a class. Rather than seeing a missed class as simply missed knowledge, they can take ownership of the learning themselves and rely on the record of previous content and the expected progress expressed on assessments to move forwards.

4. Conclusion

It is clear that the use of digital technologies for maths learning is a rich area. Teachers can leverage technology to improve student engagement, grades and understanding, while reducing the amount of administration that often accompanies large, diverse classes.

However, technology cannot be blindly used, but requires careful implementation to maximize benefits. Educational technology is a pedagogical tool to assist learning rather than a one-size fits all solution. Every class is different and will require slightly different adjustments in technology to ensure effectiveness.

EdTech is a busy field with lots of fashionable terms that change frequently. This can pose a problem as some of these terms can ring hollow and therefore make it difficult for EdTech solutions to live up to its promises. However, if technology is implemented correctly and thoughtfully then it can engage students and save teachers time which could be better spent.
Technology needs to be helpful for both teachers and students, with every feature serving some purpose.

This paper was intended to allow teachers to consciously recognise the challenges that teaching mathematics to a large group of students can pose, as well as serving as an introduction to some of the solutions made available through innovative technology.

5. About SOWISO

We have spent the last 10 years working with teachers and students to improve mathematics learning in Higher Education using digital technologies. With a particular focus on maths learning for students of other disciplines, we combine creative, interactive content with an online learning platform to make maths simple and enjoyable.

We have worked with dozens of Higher Education institutions such as universities and colleges. We operate in almost every country across the world but we are particularly focused in the Netherlands, Scandinavia and Australia. We also work with educational publishers on maths-related content.

We use a variety of techniques to leverage mathematics teaching for a broad range of students. Our platform has several features that make learning attractive and enjoyable for students and flexible and easy to integrate for teachers.

Personalized Feedback
Provides hints and feedback specific to a student's learning journey, meaning individual students get individual attention no matter how large a class is.

Adaptivity
Analyzes student comprehension and provides appropriate exercises.

Learning Analytics
Provides extensive analytic data regarding student performance and behavior for every course.

Automated testing
Capable of implementing randomized tests for students, checking and grading answers so that teachers do not have to undertake extra work.

Gamification
Teachers can activate gamification elements on our platform, allowing students to gain achievement badges for important and informal tasks.
Integration - Can be fully integrated into an LMS like Moodle or Canvas or can be used in a cloud-based form using access codes and hyperlinks.

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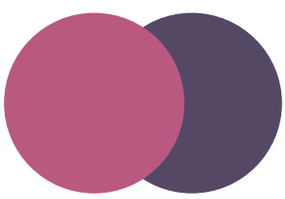

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