CENTRES FOR EXCELLENCE IN MATHS

Does using diagnostic assessment to judge student confidence, supported by interactive software, empower students to demonstrate mastery of specific topics

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OUR PARTNERS

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About CfEM

Centres for Excellence in Maths (CfEM) is a five-year national improvement programme aimed at delivering sustained improvements in maths outcomes for 16–19-year-olds, up to Level 2, in post-16 settings.

Funded by the Department for Education and delivered by the Education and Training Foundation, the programme is exploring what works for teachers and students, embedding related CPD and good practice, and building networks of maths professionals in colleges.

Summary

This action research project considers the use of a short diagnostic resource to assess student confidence in certain topics of maths by encouraging student introspection and communication.

Data was collected through two student surveys, one in October 2021 and the second in March 2022 with the participation of approximately one hundred students.

Monthly tutor reflections from five participating tutors also offered insight into how students reacted to the diagnostic tool throughout the academic year.

Results from the two surveys implies that student confidence in their maths skills increased to varying degrees and that the diagnostic resource had an overall positive impact in all settings. However, the way teachers utilise the tool is critical in order to encourage effective engagement from students.

Through the development of the simplified diagnostic assessment students were encouraged to write down their thoughts and opinions about a topic at the beginning of a lesson, which empowered teachers to create a line of communication that celebrated existing knowledge as well as influence the direction of the lesson.

Equally, results from the two surveys implies that student confidence in their maths skills increased to varying degrees between both research windows and that student confidence in using computers and the interactive software increased between the two timeframes, regardless of the type of software utilised.

The project suggests that though a diagnostic assessment can be of benefit to students and tutors, successful implementation of a positive learning environment (that includes teachers responding to student needs) will ensure more effective engagement and participation.

Contents

Background

As part of the action research development for 2021-2022, the Stamford College network partnership has focussed on the Data and Technology and Mastery themes with an action research focus on the introduction of a short diagnostic assessment to support learners returning to onsite delivery after the pandemic.

It is acknowledged that while the research focus on Mastery through the diagnostic is new, the network has chosen to continue from last year the development of incorporating technology software into the teaching and learning of GCSE maths.

The Stamford Centre for Excellence in Maths (CFEM) network is made up of fifteen establishments with five colleges involved in the action research project including Stamford College. There were approximately twenty GCSE maths lecturers in total with five GCSE maths lecturers involved in the action research teaching a cohort of approximately one hundred students in the project overall.

College goals and wider context

There are a variety of wider contexts that were considered that influenced and impacted the shape of the action research project and these included the requirement to focus on a minimum of one of the Centres for Excellence in Maths Core Themes of Activity:

1. An adapted mastery approach to mathematics
2. Approaches to contextualisation which relate maths to real-world situation
3. Motivating and engaging learners,
4. The use of data and technology within mathematics education in the sector.

Equally Stamford College aims to respond to key quality improvement targets from the college Self-Assessment Report which is to "…minimise the impact of lost learning by maximising face-to-face lesson time with additional support from specialist maths software e.g. using blended learning, flipped learning & collaborative learning using IT."

As well as the key factors above, the research team had to consider the three strands of activity as proposed in the CfEM Technology and Data theme, each of which directly relates to the teaching and learning of maths:

1. Use technology to give students direct experience of maths in ways that are new to them. There are generic and bespoke maths applications that can provide dynamic access to mathematical ideas and structures. It is proposed to develop opportunities for students to experience this in a limited number of carefully targeted key areas.

2. Further to 1, develop 'flipped classroom' approaches to learning where students use technology, particularly videos but also other technologies, in ways that allows class time to be used differently. This has the potential to allow students to develop deeper insight to the maths and achieve mastery.

3. Finally, technology can be used by teachers for formative assessment. For example, some software packages, when used with well-crafted diagnostic questions, allow teachers to identify students' misconceptions and adapt their teaching in-the-moment. (ETF 2022)

Research aims and objectives

The Stamford College maths partnership action research team chose to introduce the Mastery theme in 2021/22 alongside the Technology theme that was investigated in previous years. The action research team aimed to introduce diagnostic assessment and learning opportunities through concepts of Mastery and the use of technology (interactive maths software).

The research opportunity brought together four partner colleges to work with Stamford College to take part in the action research project. The partnership consists of Stamford College, College of West Anglia, Peterborough College, Grantham College and Moulton College. Each college utilised maths software appropriate to their setting and cohort to use and develop as part of the blended learning explorative research.

The main quantitative research tools used to gather responses to the research trials are student surveys conducted during two windows of research – October 2021 to December 2021 and February 2022 to March 2022.

Information and trends from student and tutor comments as well as ongoing monthly reflections has formed the main qualitative part research data from both students and tutors.

The data gathered will consider the impact of the diagnostic approaches, pre and post-trial activities and review how students and tutors have adapted throughout the academic year.

The diagnostic material has allowed for greater analysis of student understanding at concept level, considered the potential to offer greater personalised learning and opened up further opportunities to identify intervention needs and increase opportunities to engage and motivate students in maths.

Literature Review

Background and context

The history and implementation of mastery including the facilitation of diagnostic assessment in the teaching of the mathematics curriculum as part of the English education system is a key factor to the backdrop of the development of this action research project.

After completing action research last academic year (2020-21) that centred around online learning and the introduction of maths software, the action research this year has evolved to investigate support for students transitioning back into college-based lessons. This includes integrating mastery-based techniques into onsite sessions to further develop student understanding as well as continued implementation of specialist maths software. By building on the research findings last academic year and the positive feedback received regarding the interactive maths software, it is planned that using a mastery approach will further improve the effectiveness of using such software in a classroom environment. Equally, students will be presented with opportunities to self-diagnose their levels of confidence in maths topics to support their teachers when delivering and assessing said topic. Drawing on the existing research, the reasons for the proposed intervention will now be outlined.

Employing mastery as a teaching method and perspective was first formally proposed by Benjamin Bloom in the 1960s. Based on the ideology that "…students must attain a level of mastery…in prerequisite information before moving forward to learn succeeding information" (Hussain & Suleman, 2016), and students that do not master understanding are then provided with alternative learning methods and resources to further develop their knowledge.

The exact meaning has been refined over the years, including Hussain and Suleman's (2016) explanation in which "…materials and concepts are divided into smaller units with predetermined objectives" before an assessment of ability takes place. Hussain & Suleman (2016) also explain that the results from the assessment define the following stage. If students demonstrate mastery they move on to the next topic while those that do not are supported through alternative resources and activities.

The impact of teaching for mastery was recently explained by the National Centre for Excellence in the Teaching of Mathematics (NCETM). The group describes that "Mastering maths means pupils acquiring a deep, long-term, secure adaptable understanding of the subject" (NCETM 2021) and that "…the phrase 'teaching for mastery' describes the elements of classroom practice…that combine to give pupils the best chances of mastering maths." (ibid.)

Teaching for mastery can include many teaching strategies. For this action research, the focus is on empowering students to self-diagnose their skills and knowledge of a subject prior to delivery. The tutor can then employ mastery techniques to support students by building on their existing confidence as well as engaging in dialogue to pinpoint specific areas of required support.

By sourcing alternative methods of learning and assessment in lessons, specifically interactive maths software, students can maximise their learning opportunities and develop mastery of topics. According to Attard & Holmes (2020), using digital technologies means that ''...teachers can take advantage of the affordances of technology to vary instruction and provide student-controlled learning paths.''

Equally, as highlighted by Chappuis & Stiggins (2002) by allowing student involvement in assessment, students can ‘‘…use assessment information to manage their own learning so that they understand how they learn best, know exactly where they are in relation to the defined learning targets, and plan to take the next steps in their learning.’’

It is anticipated that by supporting student confidence and opening lines of communication between their peers, teacher and learning support assistants, we can apply mastery-based techniques more effectively in a quicker timeframe to support a successful transition back to onsite learning and engaging with maths in a classroom environment.

Managing action research

With reference to blended learning in particular and how it forms a key basis of Stamford College’s research, it is important to recognise how the term has evolved over time. Hrastinski (2019) explains that blended learning is an umbrella term and is used to describe blends such as “combining different instructional methods, pedagogical approaches and technologies, although these blends are not aligned with influential learning definitions.’’ The definition and concept of blended learning evolved through Stamford College’s action research in 2020-21. For this new academic year’s action research, the term has defined itself further due to the actions and understanding of the maths team as well as other impacting factors such as the Covid-19 pandemic and return to classroom delivery. Hrastinski (2019) describes that there is ‘‘...general agreement that the key ingredients of blended learning are face-to-face and online instruction or learning either inside or out of the classroom.’’ Stamford College’s teaching model for academic year 2021-22 is broadly a blended learning approach with a focus on maximising the class time with a teacher but also making activities available outside of lessons for students.

It is generally considered as a given that students’ ‘old’ knowledge plays an important role in the construction of ‘new’ knowledge (e.g. Vygotsky, 1978). As mentioned, recognising the extent of students’ ‘old’ knowledge is critical. By understanding a student’s entry point into a topic, the tutor can tailor a more specific learning experience to enable ongoing understanding. As Boettcher & Conrad (2016) explain, “Every course has a set of core concepts and knowledge. If learners and mentors work well together, the learners create and integrate those core concepts into their unique learning structures.”

This approach is further substantiated by a report from the National Research Council (Bransford et al 2000). It highlights the importance of two features of how students acquire knowledge:

1. finding out what students already know and
2. exploring what misunderstandings of concepts they already have in order correct their understanding.

As Boettcher & Conrad (2016) summarise:

> How can faculty get to know their students’ knowledge structure? The best approach is to increase the number of ways that information flows from the students back to the instructor. At the launch of a new topic or experience, ask students what they know or think they know about the topic.

One of the key aims of this action research project is that tutors will develop methods of gathering student understanding and confidence prior to the delivery of a topic in order to shape and mould how the subject will be taught. In a report, Dalby and Noyes (2020) highlight the issue of how lack of confidence in students resitting their GCSE can be a barrier to learning. “Negative attitudes and emotional responses to mathematics, along with poor motivation and engagement, are commonly reported problems in the colleges. Unlike in school, many post-16 students wear the badge of mathematical ‘failure’ which decreases confidence and self-efficacy” (Dalby & Noyes 2020).

Backed up by Donovan et al (1999), if a student’s “…initial understanding is not engaged, they may fail to grasp new concepts and information presented in the classroom”. This highlights the importance of being aware of what students already feel competent in, individually and as a class as a whole before launching into a topic. Dalby and Noyes (2020) also explain that by having a clear understanding of student confidence during a lesson, adaptations can be made in a timely manner to ensure appropriate support “…issues of low confidence, self-esteem and resilience with mathematics can be overcome with skilful teaching…so they make progress and become more inclined to make further effort. Timely intervention with individuals can also help avoid periods of inactivity and help them make progress” (Dalby & Noyes 2020).

Such comments represent Stamford College’s approach to delivering maths this academic year, 2021-22. To-date, we have noticed that opening lines of communication, allowing student confidence to be highlighted and the advanced integration of technology in the classroom has been a direct response to students returning to onsite lessons. The action research will consider how such knowledge and development can be sustained to shape future learning.

Learning opportunities

One key area for investigation is how students can develop their own learning paths by offering opinions of their ability levels about topics prior to the tutor delivering them. As part of action research Stamford College has renewed their licence with GCSEPod for a fourth academic year because feedback was positive regarding how students could choose their own path of learning and master key topics at their own pace. By utilising interactive learning software, according to Attard & Holmes (2020), and using digital technologies in the classroom means that ‘‘...teachers can take advantage of the affordances of technology to vary instruction and provide student-controlled learning paths.’’

Offering such variation to students in lesson can be a risk. Equally some students who already have a negative reaction to maths can feel further discouraged when being asked to judge themselves. It is hoped though that any discouragement is outweighed by “…knowing what students know, instructors can design experiences to ensure an accurate knowledge structure and then support the growth of that structure” (Boettcher & Conrad 2016).

It is also important to consider that students vary in terms of the amount of framework and structure required to support understanding in a blended learning environment:

> ‘‘...student-controlled learning paths may not be conducive to learning progress if left unmonitored, many contemporary educational apps also provide teachers with frequent formative assessment and progression data aligned to curriculum standards’’ (Attard & Holmes 2020).

Feedback from GCSEPod and Stamford College's action research in academic year 2020-21 indicated the majority of students responded well to having the opportunity to access learning not just via a lecturer in a classroom but through interactive maths software. Students explained that they felt that their own specific needs were being addressed, which Attard & Holmes (2020) indicate, ''Decreasing the need for whole class explicit teaching within every lesson allows the teacher to work more effectively to address the learning needs of individual students.''

It is planned that by encouraging students to make accurate judgements of their level of confidence in maths topics, more effective intervention can be implemented in a more timely fashion during the lesson and as part of the blended learning model.
Reflecting on the first window of research will be critical to evaluating the diagnostic material and how students interacted with it. Input from the tutor will also be key to identify how the document influenced how topics were delivered and the student cohort managed.

Covid-19 and ongoing impact

As a reaction to the Covid-19 pandemic and the UK lockdown in March 2020, Stamford College moved to an online delivery system in academic year 2020-21. Online learning impacted student engagement as adaptive learning took place. Students and lecturers both required time to adjust and upskill in order to teach or learn effectively. Indeed, as Attard & Holmes (2020) surmise, having unprepared students would result in unproductive classroom time.

Though barriers still present themselves this academic year, it is thought essential that the time students spend in lesson, with support from a tutor, is used effectively. The aim is that more relevant delivery and support can be offered by using student feedback about their confidence in particular topics. Equally, by enabling students to share their confidence in the classroom, more effective use of interactive software activities can take place. "Deciding what technology is best for specific students and cohorts and how to use it is a continuing challenge'' (Attard & Holmes 2020). However, the more detailed and accurate the student input is, the more tailored and effective the learning experience could be.

Allowing time to review practice is essential for widespread adoption of online technologies and their teaching opportunities. This is certainly true of a learning environment that is constantly evolving at speed which also affects the role of the tutor. The NMC/CoSN Horizon report (Freeman et al. 2017) highlights the difficulties faced by teachers today:
Teachers now address social and emotional factors affecting student learning, mentor students, model responsible global citizenship, and motivate students to adopt lifelong learning habits. These evolving expectations are changing the ways teachers engage in their continuing professional development, much of which involves…the use of new digital tools and resources (Freeman et al., 2017).

With reference to Stamford College's response to Covid-19 and lockdowns since March 2020, students and teachers have had to rapidly adapt to new teaching and learning strategies, delivery models and technologies. This impact has been far-reaching and it is planned that this academic year (2021-22) will retain elements of delivery and skills obtained during this disrupted period of learning.

The action research project in this academic year, 2021-22, will aim to capture how teachers and students have reacted to the ongoing Covid-19 impact and the data gathered will inform new interventions which will be evaluated to implement further lessons learned. On a broader scale this includes how teacher assessed grades shaped this academic year's student cohort as well as how lockdown and learning from home resulted in lost learning.

Such factors have played a key part in how teachers work with students this year to provide a more ‘traditional’ learning experience whilst integrating many of the skills and technologies developed in academic year 2020-21.

In conclusion, implementing mastery techniques with a focus on student efficacy in a classroom environment can present challenges. These include how effectively students judge their confidence and ability, what the teacher does with that information and how the overall structure of the lesson promotes a growth and mastery mindset. Using the findings from AR cycle 1, the aim is to minimise these barriers in order to ensure positive outcomes from the intervention.

Methods

Research design

As part of our action research in the academic year 2021-22, a team of maths teachers at Stamford College and their network partners took part in two cycles of research, one in Autumn 2021 and the second in Spring 2022. The second research cycle was framed by the results of the first cycle. After a period of reflection and evaluation of the findings, teaching practices will be refined in order to implement into teaching.

Whilst there are key barriers to consider and manage within the action research project, such as implementing new mastery elements into lessons and ensuring students provide relevant feedback regarding their perspectives, it is key to empower students with the understanding that they can express levels of confidence and understanding to their tutor and not feel judged by what they express. As part of the ongoing blended learning model that is being delivered, the aim is that small changes to delivery will encourage engagement overall.

The project aim is to improve student understanding and confidence of a range of the key most common concepts that feature in GCSE maths re-sits. This action research introduces a simplified diagnostic document that students engage with throughout a lesson that encourages thoughtful reflection and opportunities for discussion with peers, learning support assistants and the lecturer. The aim also allowed a broad scope of research to take place with all the involved colleges, including the continued use of different interactive software to identify trends in both student opinion or teacher development.

Stamford College used GCSEPod. Grantham College and Moulton College used Century, Peterborough College used Mathswatch and College of West Anglia used Learn, part of their Moodle platform.

Each college utilised the diagnostic within the set time frames to encourage standardisation, though each college could choose the topic within which the use the document. Equally, each college was instructed to use the diagnostic at the start of the lesson but teachers could determine how students interacted with it throughout the lesson. All lessons at each college were on-site following a return to more traditional lessons after two years of Covid-19 disruption.

Each college shared two student surveys that resulted in both qualitative and quantitative data which students had the option to complete through an online form or on paper. The data from both students and teachers will be used to evaluate the impact of the diagnostic form along with the continued use of maths software as part of an ongoing blended learning approach and highlight any key findings that could support the delivery of maths in academic year 2022-23.

All students and teachers taking part in the two windows of research were informed of the process, that participation was voluntary and that they could withdraw from the planned activity at any time and any data they had provided would be removed from the data set.

Student data and responses and college settings have been anonymised and all information provided, either through paper-based completion or online submission has been stored securely.

Overall, there were 99 respondents to survey 1 in October 2021 and 99 respondents to survey 2 in March 2022. Unfortunately, we were unable to question the same students in both timeframes but the network ensured that a significant number of students were polled in both surveys.

Though Covid-19 has had an impact on data gathering with reference to student attendance, it has resulted in some valuable information that will shape the delivery of maths next academic year.

Results and Discussion

Student engagement in their maths topics due to the diagnostic tool increased in all 5 colleges from October 2022 to March 2023.

The results indicate that from using the diagnostic tool, student confidence in their own maths skills and ability increased from survey window 1 in October 2021 to survey window 2 in March 2022. All five colleges saw an increase in this measure with college 2 seeing the smallest mean difference increase of 0.1 through to college 5 with a mean difference increase of 1.4.

The graph and table below highlight the difference between October 2021 and March 2022. College 5 had a lower score of effectiveness when compared to the other colleges in October 2021 but saw the largest increase of student opinion regard the tool of 1.4 points, from 2.6 to 4.0 out of five, through to March 2022.

College 1, saw the second highest increase of student opinion of 0.8 points Colleges 2, 3 and 4 all saw similar positive increases (0.1, 0.6 and 0.6 respectively).

Double bar chart 1 to demonstrate change in student opinion of the diagnostic and lesson engagement between October 21 and March 22.

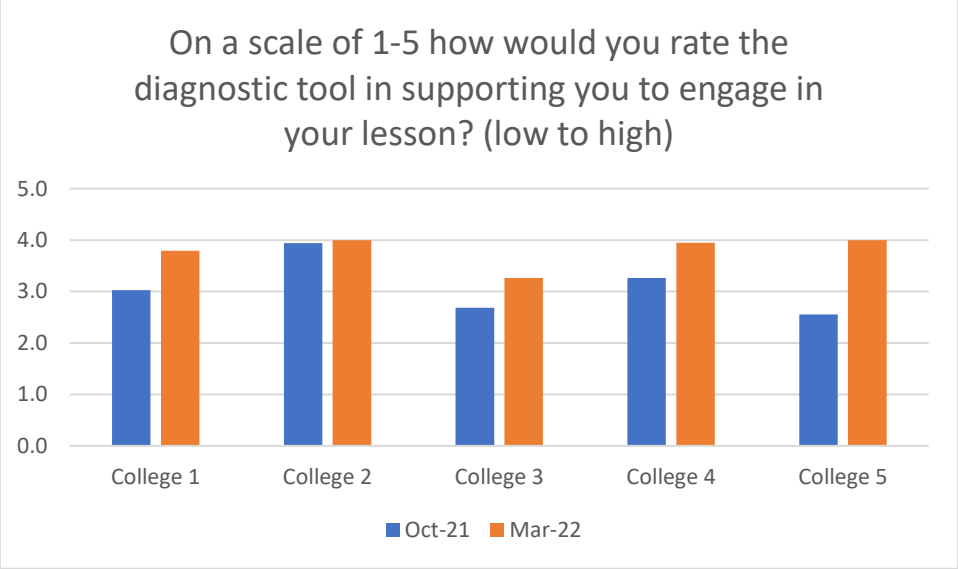

Table 1 to show mean average and difference per college of student confidence in maths ability in October 2021 and March 2022.

College	Mean average Oct 21	Mean average Mar 22	Mean average difference
College 1	3.0	3.8	+0.8
College 2	3.9	4.0	+0.1
College 3	2.7	3.3	+0.6
College 4	3.3	3.9	+0.6
College 5	2.6	4.0	+1.4

Though this perceived increase in engagement could be for a combination of reasons, it is interesting to note that across all five colleges there was an overall increase in student engagement in topics where the diagnostic tool was utilised.

The comments from students in both October 21 and March 22, whilst similar, revolve around three key areas:

1. Students appreciate how their teacher can interact with them based on their feedback.
2. Students largely feel more confident in their work.
3. Students feel more engaged as they can check their progression.

The below word cloud captures the most common words and phrases from student comments in both survey windows:

Progression features several times, as do comments related to progression. Equally, focus and confidence are common. Though the word cloud only provides a broad snapshot of student comments, it does allow some insight into overall student opinion.

When student comments are analysed in more detail, student responses indicate that when used appropriately, the diagnostic tool creates a method of communication between the teacher and the student. As one student from college 1 explains, 'I can share how I feel about topics with my teacher and get the right help' (Student 1 response – college 1).

Another comment from a student from college 2 provided insight into developing confidence and checking progression '…I can measure what I've done in lessons, so can my teacher and I can keep track of where I am'. (Student 1 response – college 2)

Record keeping and tracking progression, along with being able to talk about their answers to the diagnostic are the key themes coming from the majority of the topics.

Another student from college 3 explains '…I can show my LSA (learning support assistant) and together we make a plan. I can focus on the work and my teacher checks in on me if I need help.' (Student 1 response – college 3)

3 students from college 5 expressed similar opinions that the diagnostic prepared them for the lesson and that they appreciated the time to reflect on their prior knowledge before starting another topic. As one student summarises: 'It helps show what I can do and gives me a starting point. I don't like talking much but I can write what I know. It makes me a bit more confident and ready.' (Student 1 response – college 5).

The large majority of students were positive about engaging with the diagnostic. However, not all students found the diagnostic tool to be of use, with several citing that they did not see the relevance of judging themselves and tracking their progress either short or long term. Although there will always be students that will not engage with such a tool, it might require the teacher to change their approach to how such a diagnostic tool is deployed in a lesson.

Potentially if the diagnostic is used on a more regular basis and introduced at the start of an academic year as a support tool, student commitment and buy-in would increase.

With reference to how the diagnostic tool could be improved, though feedback was mixed overall there were some interesting changes that could be implemented as part of further research or planning for teaching next academic year.

Several comments referenced being able to have an online version of the document for storage and reference purposes. It would be valuable to trial an online version and encourage students to refer to the resource regularly and draw comparisons. One of the reasons the choice was made to use a physical document was based on how the resource was planned to be used. The sheet needed to be available on the desk for teachers to review and offer instant support if required. However, if the document was used more regularly, the storage and record keeping of the sheet could cause difficulty and online access could be a solution.

As one teacher explained, they could see the value of the document but more practice would be required to fully integrate and maximise the diagnostic sheet:

> I used the diagnostic as a starter to engage my students and introduce the topic of the lesson. It allowed students to settle and draw their attention to the maths. Some students really engaged and wrote down lots about their ability. Others were more reserved and ticked the boxes to show where they thought they were…I think the diagnostic is valuable but only if there's time to get round the students and discuss their options. There's no point doing it and not returning to it. (Teacher 1 response – college 4)

Other teachers explained how the diagnostic resource promoted relevant conversations about maths topics with their students: '…the sheet allowed me to support a quiet student who struggled with maths last year and now is hard to engage. From her written comments we talked about how I could support her, found additional resources and liaised with our LSA for in-class guidance.' (Teacher 1 response – college 2)

Equally a teacher from college 5 highlights how the diagnostic reduced emotional barriers that students can have when faced with certain topics: '…they (students) can go from zero to one-hundred with some topics, maths can trigger strong emotions. I used the sheet to encourage students to quantify their thoughts. As a result, I was able to arrange additional support and signpost students to sites like CorbettMaths for helpful videos' (Teacher 1 response – college 3).

Consequently, though the data has shown an overall increase in student engagement of lessons, it is key to be aware that student engagement can fluctuate for several reasons and there are various impacting factors that can influence how a student feels about maths and how they engage in topics.

Students' confidence in their maths ability increased in all 5 colleges from October 2021 to March 2022.

The results indicate that student confidence in their own maths skills and ability increased from survey window 1 in October 2021 to survey window 2 in March 2022. All five colleges saw an increase in this measure with college 2 seeing the smallest mean difference increase of 0.1 through to college 2 with a mean difference increase of 0.8.

The graph and table below highlight the difference between October 2021 and March 2022. College 2, using the Mathswatch platform, experienced the smallest difference between the two research windows but has the highest scores out of five for both windows (4.3 and 4.4). College 5 had the lowest confidence score of 2.1 in window 1 but received the second highest score in window 2.Colleges 1, 3 and 4 all saw similar positive increases (0.2, 0.9 and 0.9 respectively).

Double bar chart 2 to demonstrate change in average student confidence in maths in all five colleges between October 2021 and March 2022.

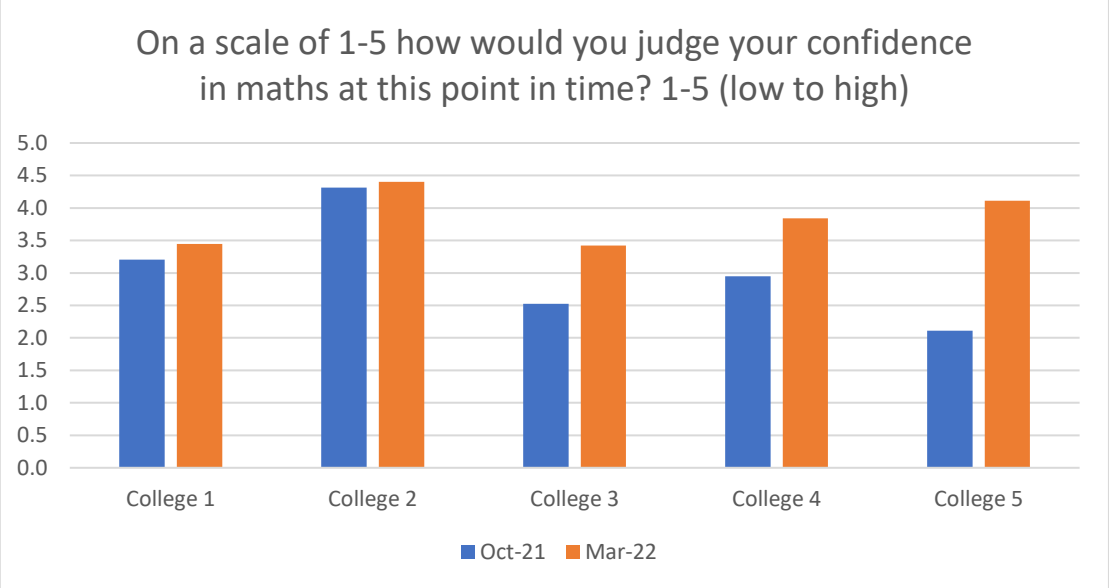

Table 2 to show mean average of student confidence in maths between October 21 and March 22 and mean average difference.

College	Mean average Oct 21	Mean average Mar 22	Mean average difference
College 1	3.2	3.4	+0.2
College 2	4.3	4.4	+0.1
College 3	2.5	3.4	+0.9
College 4	2.9	3.8	+0.9
College 5	2.1	4.1	+2.0

After disruption to learning and access to lessons as a result of the Covid-19 pandemic in 2020 and 2021, it was hypothesised that student confidence in their mathematical skills would be lower at start of academic year 2022. Compounded by the fact that students experienced centre assessed grades in summer 2020 and teacher assessed grades in 2021, some students appear unsure of their ability, which is also reflective in their comments.

One student from college 1 explained '…I don't know what I can do now. I don't like maths anyway but I'm not used to doing maths in lessons or exams. I think I'll fail again' (Student 2 response – college 1). A student from college 3 said '…my predicted grade was a 5 but I left school with a 3. I had to change my course to come to…college so maths is a challenge for me making me less confident' (Student 2 response – college 3).

A student from college 5 summarised their feelings as '…still a bit lost with everything really. I've not done a maths exam because of Covid so I don't know what I'm good at. I'm nervous about being in college and lessons after doing some online lessons last year so no I'm confident with it.' (Student 2 response – college 5).

However, some students expressed they were feeling confident and relishing the opportunity to prove themselves: '…Being back at college has been good me. I get the help I need and I'm aiming to get a 4 this year' (Student 2 response – college 2). Another student from college 1 referenced the diagnostic tool and how it supported to reframe knowledge. 'In class, can use the sheet to check what I know and what I need to learn…it makes me feel good about my skills. (Student 3 response – college 1).

During the second window of research in March 22, though student comments continue to be mixed, the general trend is that most students felt more comfortable in the classroom and more confident in their skills, which reflects the data from the surveys.

One student commented '…my teacher shows me how maths will be used in my course. I can check how I feel using the (diagnostic) sheet. I am good in class but still a bit worried about exams.' (Student 3 response – college 5).

Another student confirmed how the diagnostic tool has been a positive experience for them. 'It showed whether I progress or if my confidence improved in specific topics of the lesson' (Student 3 response – college 3).

It could be expected that students would feel more confident in their maths skills during the second window of research. More topics have been covered, mock tests would have been completed and additional support could be in place. Equally, learners would have had an opportunity to sit the November 2021 series of GCSE Maths.

However, several comments from teachers also indicate how the use of the diagnostic activity in both October 21 and March 22 has had some positive impact. One teacher explained how the sheet allowed students to concentrate and focus:

'…some students it zoned them into the lesson. We used it as a starter but because there were not mathematical it wasn't seen as a test. Some of the quiet students used it to check their knowledge and showed it to me during the lesson. I used the sheet through the time to get them back on track and focus on their own work' (Teacher 1 response – college 1).

Another teacher concludes; '…it needs to be used more and developed into more lessons as part of a scheme of learning but most students used it well. Some felt listened to and we used the document to plan the lesson together. It's still not quite there with my hard-to-reach students, they don't want to write how they feel but I'll check I do it as a resource to engage them more. (Teacher 1 response – college 5).

Conversely, another teacher from college 4 expressed an opinion that they would expect student confidence to naturally improve through an academic year, regardless of the diagnostic tool: '…I'd need to use it in more lessons to check the effectiveness. Some students have reacted well and it's generated good conversations. By March I'd expect all my learners to have developed confidence in some topics or else I'd feel I've failed them. (Teacher 2 response – college 4).

In conclusion, the challenge remains how to engage the hardest-to-reach learners who are already disaffected with maths. The diagnostic sheet has potential as it allows meaningful conversations to take place between student and teacher as well as with learning support or peers.

If used regularly, the sheet could become part of the lesson structure, especially if students see the benefit of the tool from the start of the academic year. It has been positive to note that some of the comments from students regarding improving the sheet have been valuable and adaptations could be employed if the document was adapted further. As referred to earlier, several students indicated that if the diagnostic sheet was made available online, they might engage with it more and others explained that they would prefer more time with the document. Equally, some students highlighted that the sheet layout could be optimised to encourage more writing.

Next academic year could see an evolution of the diagnostic that trials some of the improvements highlighted by learners. Equally, there is potential for different versions of the resource so students can work with the one that most suits them.

The intervention of interactive software was judged effective by students at all 5 colleges – increasing in the second survey windows in March 2022.

Students continue to evaluate the intervention software positively. All colleges participating in the action research this academic year saw an increase in students judging the interactive maths software as effective between research window 1 in October 21 and window 2 in March 22.

Double bar chart 3 to show mean average scores for how students assess their interactive maths software in supporting their progression in maths between October 21 and March 22.

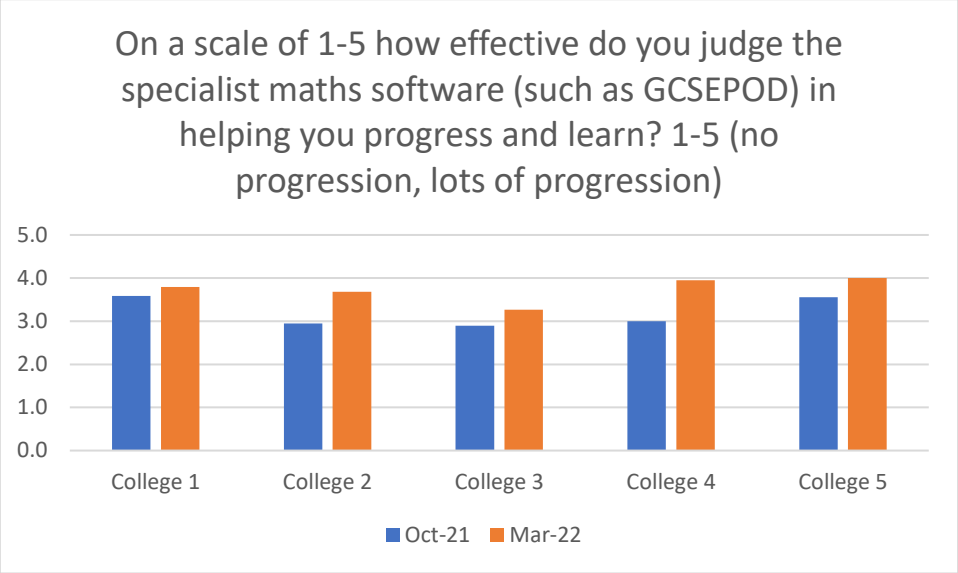

Table 3 to show mean average scores and mean average difference for how students assess their interactive maths software in supporting their progression in maths between October 21 and March 22.

College	Mean average Oct 21	Mean average Mar 22	Mean average difference
College 1	3.6	3.8	+0.2
College 2	2.9	3.7	+0.8
College 3	2.9	3.3	+0.4
College 4	3.0	3.9	+0.9
College 5	3.6	4.0	+0.4

In October 2021 scores ranged from 2.9 out of 5 for colleges 2 and 3 to a high of 3.6 for colleges 1 and 5. The small range could be explained by the timing in which the data gathering took place. By mid-October it could be argued that students are still familiarising themselves with their circumstances and not fully embedded into the learning process.

As one lecturer from college 1, that used GCSEPod, explained, there were circumstances outside the lesson that impacted the use of the interactive maths software:

> Due to our merger, we lost access to a lot of systems. Our MIS team wasn't able to support us with student management which resulted in a poor experience for students. Even some returners couldn't access GCSEPod. New student data couldn't be upload by .csv files for a couple of weeks meaning we had to change how we launched the software this year. (Teacher 2 response – college 1)

As always, it is interesting to consider all the external factors that can impact change or implementation of resources. Such factors can have long-term repercussions that can disrupt lessons for students and tutors.

The data implies that colleges 2 and 4 saw the most significant increase in interactive software impact with increases of a mean average difference of 0.8 and 0.9 points respectively.

However, it is college 3 that had the lowest average score for both window 1 in October 21 and window 2 in March 22. As a student from college 3 implies, training and opportunities to use the interactive software in lessons could be a reason why the student judgements were the lowest between both time frames:

> I like using the software and it's a decent revision tool. But it's hard to learn and for a long time it wouldn't load. I started to get annoyed with it so didn't use it as much. I think if we had more time to get to know the systems, or shown more by my teacher I'd be better at using it. When it works it works well…I'd like to use it more. (Student 4 response - college 3)

A draft hypothesis at the start of the project was that college 1 in particular, where delivery of maths on academic year 20-21 remained fully online, would be more effective in the launch and embedding of interactive maths software into classes. Equally with college 1 using the same software (GCSEPod) for four years, it was predicted that the impact of the software would have been more well received by students. However, while college 1 received the joint highest mean average score in October 21, college 1 also scored the smallest positive increase between the two timeframes.

Indeed, one student from college 1 commented that they felt tired from using software so often and instead much preferred the interaction provided by the diagnostic sheet:

> I don't mind using GCSEPod but I used it a school and a lot last year at college. It gets a bit repetitive doing the same…over and over again. I don't always get my work checked either. I prefer being able to speak to my teacher and get help straight away. (Student 4 response – college 1)

One teacher from college 1 expressed similar in their reflections: 'I do find the software quite repetitive. Hardly any students complete the homework set. I need to spend to time thinking about how I can integrate it more into lessons to revitalise how students use the resource.' (Teacher 3 response – college 1)

As no college environment is the same, nor the student cohort, it is key as part of planning for maths that a variety of activities and teacher support is made available throughout an academic year to ensure all students feel supported based on their learning styles.

There are options for modern interactive software to provide more individually tailored learning experiences for learners. This can take time to implement however, and requires clear understanding from teachers and students in order for the maths software to become an effective resource.

Topics that students felt they required support in are common across all 5 colleges and there is little variation throughout an academic year (October 21 to March 22)

The tables below summarise the top three topics per college that students identified as requiring support in. The data is split into the two survey periods of October 2021 and March 2022.

Within the first window of October 21 there is little variation in the top three topics but it is interesting that fractions are the most frequent choice for four out of five colleges, with thirty-one responses in total.

Algebra and angles also feature in the top three topics for each college which suggests that at the start of an academic year fractions, algebra and angles are prevalent in the minds of our students.

This could reflect missed learning opportunities at secondary school or college or be the most common subjects that students associate with maths or exams.

The second table (March 2022) constitutes of the top three topics students felt they required support in toward the end of the teaching syllabus. Again, fractions and angles feature in the data sets of all five colleges with algebra.

Tables 4 and 5 to demonstrate most common subjects identified by students that they would like support with in October 2021 and March 2022.

Oct-21

College 1 (Total)	34	College 2 (Total)	18	College 3 (Total)	19	College 4 (Total)	19	College 5 (Total)	9	Total responses 99
Ratio	19	Fractions	10	Fractions	8	Fractions	7	Fractions	5	
Angles	6	Algebra	4	Angles	5	Algebra	4	Algebra	2	
Percentages	3	Angles	4	Ratio	3	Angles	3	BIDMAS	2	

Mar-22

College 1 (Total)	29	College 2 (Total)	19	College 3 (Total)	19	College 4 (Total)	19	College 5 (Total)	13	Total responses 99
Ratio	19	Fractions	6	Ratio	12	Angles	9	Area	6	
Shapes	6	Ratio	5	Fractions	5	Fractions	5	Angles	4	
Fractions	4	Angles	3	Percentages	2	Algebra	2	Fractions	2	

The data implies that though there is some variation, the top topics remain relatively constant throughout the academic year. This is not surprising in the sense that the timeframe is relatively short between both surveys (six months) and that such topics could potentially be areas of development that students have cited for many years.

What is key is that though data shows student confidence in maths has increased between the two surveys, those top topics identified in October 2021 as requiring further support feature significantly in the second survey of March 2022.

However, it is important to recognise that a small sample of ninety-nine students across the five colleges were surveyed and that the data is indicative of a small cross-section of students. Such responses reinforce that learning maths can be a challenge for learners, regardless of the learning environment.

It would be beneficial to scale-up the sample size and frequency within which such a question is asked. For example, if a larger sample size was questioned monthly throughout an academic, it could help identify more conclusive trends and support teachers in targeting those specific topics.

Conclusions and Recommendations

Conclusions

1. **Student engagement in their maths topics due to the diagnostic tool increased in all 5 colleges from October 2022 to March 2023.**
   The successful implementation of a diagnostic sheet that does not specifically test students but generate targeted conversation can empower students to develop confidence in their understanding of maths. However, successful implementation is complex and requires sufficient time to generate student buy in.

2. **Students' confidence in their maths ability increased in all 5 colleges from October 2021 to March 2022.**
   Using interactive software to develop maths skills can polarise student opinion both positively and negatively. It can be used to supplement additional learning and if not implemented correctly can negatively impact student engagement.

3. **The intervention of interactive software was judged effective by students at all 5 colleges – increasing in the second survey windows in March 2022.**
   Alternative methods of delivery are required to support all needs of students in a classroom. Those students who felt unable to engage with the diagnostic tool (to the point that they did not use it in maths lessons) require guidance through other means. Diagnostic activities and interactive maths software can complement, not replace tutor directed lessons.

4. **Topics that students felt they required support in are common across all 5 colleges and there is little variation throughout an academic year (October 21 to March 22).**
   Maths topics that students find difficult feature throughout an academic year even after specific lessons have been taught. Regular reviewing of such topics throughout a scheme of work could improve student confidence in their ability to understand and engage with such subject.

Recommendations

1. If launching a diagnostic sheet into maths delivery a planned structure of training and adaptation is required for both teachers and students. This requires time and resource with regular reviews and development, to maximise the potential of the activity.

2. Consistency and an early launch is essential for successful implementation of any new practice, including the diagnostic activity. The introductory phase early in the academic year is key to ensure all parties are committed to and understand the impact of launching such a resource, including allowing teachers and students to collaborate and offer feedback such as improvements and development. After all, it will be the teachers who will be encouraging students to engage with the diagnostic as part of a supplementary tool to their maths delivery.

3. Due to the polarising nature of the diagnostic activity and to support learners that do not engage with such a resource it is key to identify alternative methods of capturing feedback to ensure all learners feel heard and valued.

4. Be aware that positive results will not be instant. Implementing a diagnostic activity that focuses on student feeling and emotion to assign a level of competence requires cycles of research as both tutors and students learn and adapt to the resource.

5. Ensure student feedback is actioned effectively. They are the end-user and can offer key insights that can support the improvement of such a resource.

6. Review and revisit topics that have already been taught in an academic year based on the diagnostic activity. Students require time to understand transferable knowledge in order to apply it to different situations. The fact that topics students would like support in changes little between both surveys indicates those subjects require regular recaps in order to support the development of student confidence which could improve student engagement of questions related to that topic.

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Appendices

1. Sample student survey.

Student questionnaire form 21-22

Please complete the following questions as part of the Centre for Excellence in Maths programme	
College name	Stamford College
Date of questionnaire	

Please answer the questions below:

1. What course are you studying at college?

2. On a scale of 1-5 how would you judge your confidence in maths at this point in time?
(1 = not confident at all, 5 = Extremely confident)

1	2	3	4	5

3. Why did you choose that level of confidence for question 2?

4. Name 1 specific topic in maths you feel you have improved in since the start of term in September.

5. How has the student diagnostic tool supported you in lessons?

6. Can you make one suggestion that would improve the student diagnostic tool?

7. On a scale of 1-5 how effective do you judge the specialist maths software (such as GCSEPod) in helping you progress and learn?
(1 = not helping me progress at all, 5 = helping me to progress a lot)

1	2	3	4	5

2. Sample reflection form

CENTRES FOR EXCELLENCE IN MATHS

Stamford College
Part of the Inspire Education Group

Monthly observation and reflection form 21-22
October / November / December / January / February / March

General Information	
College name	
Tutor name	
Brief summary of progress	
Identify the key progress points of the project since the last report	
Identify any areas for further development and potential improvements	
One sentence summary of reflection of progress including the course / topic	
Reflection	
Some points to consider… • How are students responding to the project/ILT/software? • Preparation and up-skilling on ILT/software - has it been for you? • What problems have you encountered (if any)? • What changes/developments have you made/introduced since last month? • Has feedback from students impacted on the project?	

3. Blank diagnostic form

GCSE Maths Mastery **Name:**

Use the grid below to demonstrate to your teacher how confident you are in the below aspects of key topics using the 5 step guide

1. Write down the subject you are working with.
2. Indicate your feelings about the subject at the start of the lesson by writing the word 'before' in one of the boxes from Hard to Easy
3. Indicate your feelings about the subject at the end of the lesson by writing the word 'after' in one of the boxes from Hard to Easy
4. Add your comment to the 'What supported your progress' column?' to explain what worked for you in the lesson.
5. Give this form back to your tutor.

Lesson topic (write down subject / element of subject below)	Hard *I'd find this tricky to answer without guidance*	Fairly hard *I'd give it a go but not really sure where to start*	Okay *I'd need someone to check my calculation*	Fairly easy *I could probably do this and get the right answer*	Easy *I could help somebody else with this and explain how to work out*	What supported your progress?