

Think Education: The Role of Online Enrichment in Inspiring Students to Study Post-16 Mathematics

Claire Baldwin CMathTeach MIMA, MEI and Cath Moore, MEI

How do we create an environment where students *want* to study mathematics post-16 and progress to choose STEM-rich degrees and careers? Students are often told, correctly, that studying maths at A-level will open doors to options at university and beyond [1], but are we making the most of opportunities to develop a desire in students to study mathematics for its own inherent interest and to exemplify its diverse applications in their lives and careers?

One way to do this is to supplement the mathematics curriculum with high-quality enrichment. In this article we will look at what enrichment is, the range of ways in which it is provided and what we, as a mathematics community, can do to support effective mathematics enrichment. We will centre this around a case study of an enrichment programme run by the Advanced Mathematics Support Programme (AMSP).

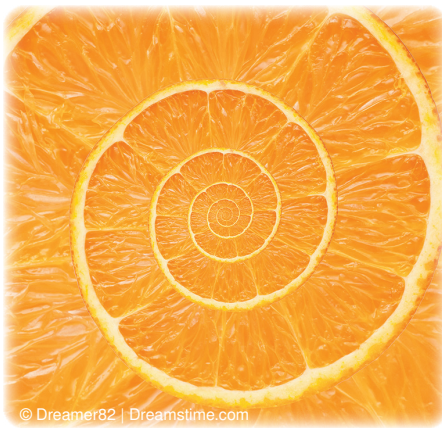
What is enrichment?

The published literature fails to reach a unique definition of *enrichment*, defining this as ‘under-researched, under-conceptualized and under-theorized’ [2, p. 225]. Concepts such as a *rich* learning environment or *rich* learning experience are common, as is the notion of supplementing the student learning experience beyond that which would take place within the curriculum. What constitutes *rich* is hard to define. It might mean enhancing the student learning experience through exposure to the wider cultural history of mathematics, deeper learning about the underpinning concepts of topics covered in class, or extension or acceleration programmes that progress students beyond the mathematics that is commonly studied at their age.

The literature (e.g. [3]) highlights that the participants in enrichment are often selected on predetermined criteria, such as the highest attainers or students from disadvantaged backgrounds. This has the potential to create a lack of opportunity between learners, when in fact, enrichment is beneficial to all.

For the purposes of this article, we will use our own definition of enrichment: Mathematical activities which enhance the learning experience beyond that which would be experienced in the mathematics classroom when following the prescribed curriculum. We will focus on enrichment for students aged 11–16. Common models of student enrichment include:

- In-lesson enrichment
- In-school enrichment
- Mathematics competitions
- Visits to universities or employers
- Online enrichment



The benefits of enrichment

Research outlines many benefits for students that arise from engagement in an enrichment activity, including developing problem-solving skills and collaborative learning. Sustained engagement develops problem-solving skills (e.g. [3]) and allows students to demonstrate creativity in mathematics, which might be missing in standard classroom activities. Collaborative learning provides a unique opportunity for students to engage with others who have similar interests and discuss their thinking in a new environment.

The medium of delivery is also important; students attending an enrichment event at a higher education (HE) institution frequently report the benefits of having this reference point when making decisions about their next steps in education. They may never have visited a university before; such exposure allows students to see themselves in what might otherwise be viewed as an environment that is not for them. These visits are an opportunity that cannot be replicated in the classroom and complement the enrichment that teachers provide.

Careful enrichment design involves selecting a diverse range of speakers, which allow students to see how mathematics is used in a range of situations – including careers new to them – thereby increasing the potential for mathematics to be seen as aligned with other subjects in which students have a keen interest.

Note that one of the key benefits of enrichment reported to us by students is that of enhancing their own mathematical skills and their confidence and interest in the subject, the value of which must not be underestimated.

The balance of focus on each of the benefits – namely the mathematical, personal and social aspects, the support for mathematics learning in school and the exposure to HE [3] – is a critical part of the design of effective enrichment activities. Consideration of the inputs and desired outputs (impact on learners and their teachers) is important [4].

Online enrichment: A case study

Here we present a case study of an online enrichment programme led by the AMSP. The authors are employed by MEI, which manages the AMSP.

The events

The AMSP, and previous related programmes, have provided enrichment events for 11 to 16-year-old students for over 10 years. Many are hosted by universities; these are aspirational for students, particularly those from disadvantaged backgrounds, for the reasons outlined above. On average, 95% of teachers attending these events reported that their students leave the event better informed about the benefits of studying mathematics at level 3.

With the 2020 school closures due to the Covid-19 pandemic, we continued to enrich students and fused this with our expertise in engaging students via online tuition to provide sessions that students accessed from home. We provided something that is difficult to achieve in face-to-face settings and proactively used the online environment. Here we discuss some of our interactive sessions that students joined independently from home.

How much is too much?

We looked at the mathematics behind the game Pig [5]. In our version of this game, players roll a die, adding the number to the running total for that round until they bank the total or the dice shows a 1, at which point the score of the round resets to zero and it is the next player's go. The aim of the game is for each player to strategically make decisions so they are the first to bank a total score of 100. This is the same as the concept behind the Pass the Pigs game, albeit with different scoring [6]. The strategy is in deciding when to roll and when to bank the round total.

After students had played the game, we looked at the mathematics behind the strategy. As students were joining online, we gathered their data through an online form and showed in real time how their scores affected a graph of the overall results. In repeats of the event, we aggregated the scores to allow students to feel part of a larger community taking part in this experiment.

Are you psychic?

We developed an app for students to use Zener cards [7] to test their psychic ability. These data were used to generate a bar chart showing their own scores and also a combined bar chart so that they could compare anonymously with others in the session [5].

Which career?

Over time, we have found that the need for these online events has diminished, and we have transitioned, on the basis of our experience, to focusing on 'Which career?' online panels, as this type of event provides something that is not easy to do in person. The panel event involves three early career professionals, who talk about their career path and how they use mathematics in their role. This is a fantastic vehicle for sharing information about university courses and apprenticeships from people relatively close in age to the students.

Many organisations visit schools to talk with students; this usually involves one person visiting a local school. Our careers panels have three professionals, who can be anywhere in the country or overseas; our event in November 2024 had over 2000 student attendees, demonstrating a continuing demand.

In most schools, the 40-minute event is streamed into classrooms. We host on different days and times to fit a variety of lesson timetables and allow access for all students, regardless of prior attainment and background.

Interaction is important in engaging students; we provide two routes for students to ask questions through the moderator of the panellists after each has been given the opportunity to talk briefly, making the questions pertinent to them and their situation. Some panellists share their simple trajectory towards their current position from GCSE, while others talk about a more convoluted journey. These are important messages for students to hear: your initial choices do not limit your possibilities; you can change direction and achieve success in very different places from where

you thought you might; you do not need to decide your whole life while studying your GCSEs.

We often have a theme to the panel, sometimes inspired by other projects happening in the world such as Apprenticeship Week and Green Careers Week. The diversity of the panel is also a consideration in terms of age, ethnicity, gender and work specialism. Students engage more with people they consider to be closer to their own age, perhaps because their success seems more attainable or because they seem more like them.

Conclusion

Our experience, and the reflection we undertook, allowed us to examine what we wanted enrichment to look like in the current climate. The online events that engendered the most engagement and positive teacher feedback were those where the students had an experience that was unlikely to be replicated in the classroom. This could be because they were part of a large experiment, as we outlined above, or because they had access to professionals that they would otherwise be unlikely to meet.

However, while online events can offer an opportunity for students to encounter new mathematics or to see where their current studies can be used post-16, we know that they do not offer the opportunity for students to experience an institution such as a university, which would also raise their aspirations. This may be more impactful, especially for students who do not have a family history of engagement with HE and for whom supporting the development of 'maths capital' is crucial [8]. For this reason, although online can be an easier to access, we have discontinued enrichment events looking at mathematical topics, as these can often be better served by an event hosted at a university.

We have continued our careers panel events, as these allow students from across the whole country to ask questions of professionals, who can answer questions from their office, without the time and carbon emissions from travelling to a school.

The most effective enrichment offers a breadth of rich mathematical experiences in school, online and outside the classroom; as a mathematics community, we can join together to support all of these. The opportunity for students to have mathematical experiences outside their school is invaluable. Access to outreach departments at universities can engage students within an environment that develops an interest and enthusiasm for further study and exposes students to the variety and beauty that is the study of mathematics.

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