CASE STUDY

Engaging students via interactive lecture activities inspired by common classroom practice

Cerian Brewer, School of Mathematical Sciences, University of Nottingham, Nottingham, UK.
Email: cerian.brewer1@nottingham.ac.uk

Abstract

This article summarises the author's experience transitioning from Further Education (FE) to Higher Education (HE) teaching in 2022-23. It identifies areas for concern in the author's setting and outlines the author's strategies for overcoming these obstacles, utilising their background in FE. In particular, this article explores common, engaging classroom activities and outlines why these activities require adapting for use in HE. Inspired by these classroom activities, this article presents a selection of interactive lecture activities promoting student engagement via formative assessment, adaptive teaching, and student ownership. It summarises how the activities have evolved over time and reflects on their use. Finally, the author reviews the success of the activities, discusses students' reactions to them, and outlines future plans.

Keywords: engagement, interactivity, formative assessment, adaptive teaching, student ownership.

1. Background

The COVID-19 pandemic has had a massive effect on education over the last few years. Anecdotally, it is common to hear colleagues discuss the effect of the pandemic on student attendance and engagement, with lecture theatres sometimes containing only a handful of students, and students being reluctant to engage in activities: this is demotivating for staff and students alike, and a common concern in the author's setting.

The author has predominantly been engaged in service teaching since joining the HE sector, teaching maths for engineering students. This comes with its own difficulties since these students did not choose to study maths at university: peers highlight attendance and engagement as particular areas for concern when teaching engineering students.

Whilst preparing teaching materials, the author has targeted student engagement in the hope that this might also lead to improved student attendance. The aim has been to promote student engagement via interactive lecture activities, based on common, engaging classroom strategies, with a particular focus on formative assessment, adaptive teaching, and student ownership. The author has also aspired to create active rather than passive learners, and to re-ignite students' enthusiasm for learning in person and encourage students back to the lecture theatre.

The benefits of interactive lectures are well established and have been a topic of discussion for many years. Interactive lectures allow more time to think than passive lectures, allowing students to determine their own understanding and to ask questions (Rodger, 1995). Mannison et al. (1994) report that students' involvement, morale, and interest in the lecture material is positively impacted by the inclusion of interactive teaching strategies, and Rodger (1995) finds that students "*overwhelmingly prefer*" interactive lectures, for example commenting "*The interactive format was very helpful and made the class more interesting*."

In more recent years, Robson et al. (2022) report that lectures have become more interactive since the pandemic, and participants in their study recognise the importance and value of interactive teaching, indicating that lectures in a post-pandemic world should make greater use of interactivity. In fact, Robson et al. (2022) report that most staff would not return to conventional lecturing post-pandemic, instead favouring more interactive lectures.

This article focuses on the development and implementation of a selection of interactive lecture activities promoting student engagement in a level 2 maths module for around 80 engineering students. Section 2 reviews a selection of pedagogical tools that the author aims to incorporate into the activities: in particular, formative assessment, adaptive teaching, and student ownership. Section 3 introduces common, engaging classroom activities that promote student engagement via the aforementioned tools and outlines why they require adapting for use in HE. Section 4 presents the interactive lecture activities that have been inspired by these common, engaging classroom activities, and summarises how they have evolved over time and provides general reflections on their use. Finally, section 5 reviews the success of the activities, discusses students' reactions to them, and outlines the author's future plans.

2. Overview of pedagogical tools

The benefits of formative assessment are widely acknowledged throughout the education sector. Black and Wiliam (2010) argue that formative assessment should be at the heart of effective teaching, and Stiggins and DuFour (2009) describe formative assessment as "*one of the most powerful instructional tools available to a teacher*". This article considers the use of formative assessment, embedded in a set of interactive lecture activities, as a tool for boosting student engagement, which Stiggins (2002) claims is more meaningful when teachers embrace the idea of assessment *for* learning, rather than assessment *of* learning.

To be most effective, Stiggins and DuFour (2009) advocate the use of formative assessment continuously, whilst learning is happening, rather than using it periodically. As such, the activities presented in this work have been used regularly to support day-to-day learning. In the specific context of teaching maths for engineering, formative assessment is also encouraged by Sazhin (1998).

If used properly, the evidence gained from formative assessment should be used to adapt teaching (Black and Wiliam, 2010). A teacher's ability to adapt is another key component of effective teaching according to Darling-Hammond and Bransford (2007) and Hattie (2008). So-called adaptive teaching describes a teacher's unplanned response to a stimulus, for example a student contribution or misconception, which deviates from the lesson plan (Hardy et al., 2019). Adaptive teaching requires the teacher to monitor students' understanding and classroom proceedings and use this monitoring, along with subject and pedagogical knowledge, to alter instruction to best support students' needs (Duffy, 2006, Vaughn and Parsons, 2013). These alterations should focus on meeting the identified needs of students whilst retaining high expectations for their learning (Hardy et al., 2019). Adaptive teaching has also been described as an important factor in ensuring equal opportunities for students to achieve their goals (Hardy et al., 2019). The activities presented in this work have therefore been designed to promote adaptive teaching and to allow for flexibility.

Formative assessment can also contribute to student ownership of learning (Bloom, 1984) and the promotion of student ownership via formative assessment strategies has been shown to result in high student engagement (Brookhart et al., 2009). Students can feel empowered when they take an active role in their education and become meaningfully engaged in their learning: taking ownership in this way can promote goal setting, self-assessment, and self-determination (Chan et al., 2014). As such, the activities presented in this work have been designed to encourage student ownership of learning.

3. Overview of classroom activities

This section introduces the common, engaging classroom activities that have influenced the author, and highlights reasons why they may need adapting for use in HE. It summarises links to formative assessment, adaptive teaching, and student ownership also.

3.1 Questioning with mini whiteboards

A common classroom activity promoting formative assessment is questioning with mini whiteboards. Swan (2005) recommends this strategy and refers to mini whiteboards as an "*indispensable resource*". The key reasons for this endorsement are summarised below.

When questioning with mini whiteboards is implemented, students can simultaneously present their responses to the teacher and/or to each other, promoting a 'no hands' approach in which the teacher doesn't need to rely on the same students putting their hands up to volunteer answers. It is possible to see at a glance what every student is thinking when they hold up their ideas, and a variety of responses can be collected, for example written or drawn solutions, which can allow teachers to ask new kinds of questions, often beginning "*Show me*..." (Swan, 2005). Overall, it is a quick and effective way to check students' understanding.

As well as promoting formative assessment, this strategy can encourage adaptive teaching since the teacher's instruction can be altered based on students' responses. This gives students an active role to play in their learning which can, in turn, support student ownership.

This strategy needs adapting for HE, however, due to the (potentially very large) number of students present and the (correspondingly large) size of the teaching rooms, not to mention the logistics of distributing mini whiteboards and pens to students. What is perfectly feasible for 20-30 students in a classroom environment becomes an impractical endeavour in an HE context. Section 4 discusses the interactive lecture activities, inspired by questioning with mini whiteboards, that have been developed with these issues in mind.

3.2 Student reactions

The term student reactions is used here to cover a broad range of informal teaching strategies that are used to gauge students' understanding and progress. As such, they can act as formative assessment tools as well as being used to judge the pace of lessons.

A common classroom activity for assessing students' understanding of a problem, after attempting it, is asking students to rate their understanding with a thumb up or down (or somewhere in between). Similarly, asking students to rate their confidence before attempting a problem can provide useful feedback for the teacher. Other strategies for checking confidence/understanding include having one-to-one conversations with students and questioning the class; students asking questions can also give a good indication of their understanding. Picking up on visual cues is also helpful, for example students might look confused, in which case the teacher can provide support.

If students find a certain concept or example difficult, the teacher can choose to spend longer going through it or provide additional scaffolding (Wood et al., 1976). Conversely, if students demonstrate understanding of an example or concept, the teacher can move onto more challenging problems. Using student reactions as a formative assessment technique therefore allows for adaptive teaching and the teacher can alter the pace of the lesson based on students' reactions. Other visual cues, such as students putting their pens down after finishing an example, can also feed into this.

Judging student reactions in a classroom environment is achievable but, due to the (potentially very large) student numbers and room sizes, this strategy needs adapting for HE. Section 4 outlines the activities that have been designed with student reactions in mind, for specific use in HE.

3.3 Worked examples

Worked examples are a popular instructional device which provide an expert's solution for a student to study and emulate; typically, a worked example includes a statement of a problem followed by a model solution, usually presented in a step-by-step fashion (Atkinson et al., 2000). In terms of cognitive load theory (Sweller, 1988), worked examples are a valuable tool since they reduce the cognitive load during learning (Atkinson et al., 2000).

Trafton and Reiser (1993) claim that the most efficient method of study is to present a worked example immediately followed by a similar problem for students to solve, namely a worked example-problem pair. In this case, students use knowledge gained from the worked example and apply it to solving a new problem. Having access to a model solution can also act as scaffolding (Wood et al., 1976) for students.

Similar methods are adopted by Sweller and Cooper (1985), who find that students studying worked example-problem pairs perform significantly better than those simply solving problems, and more recently by Atkinson et al. (2000), who find that lessons incorporating worked example-problem pairs produce better outcomes than lessons presenting a series of worked examples followed by a series of practice problems.

Worked example-problem pairs are a common classroom activity and lend themselves well to adaptive teaching: whilst presenting a worked example, or whilst students work through a similar problem, the teacher’s instruction can be altered based on students’ understanding/misconceptions etc. Allowing time for students to attempt problems themselves can also promote student ownership since students take an active role in their learning.

Although worked example-problem pairs lend themselves well to an HE setting, due to (potentially very large) student numbers and room sizes, it is difficult to check students' understanding of worked example-problem pairs and/or to provide appropriate scaffolding. This is perfectly manageable for 20-30 students in a classroom using techniques discussed previously, for example asking students to rate their understanding with a thumb up/down/somewhere in between, or simply picking up on visual cues. Section 4 describes the activities that have been designed to allow for understanding checks and scaffolding whilst using worked example-problem pairs in an HE setting.

4. Overview of activities adapted for HE

This section presents the interactive lecture activities, inspired by the common, engaging classroom activities described in section 3, that have been designed to promote student engagement via formative assessment, adaptive teaching, and student ownership. It also summarises how the activities have evolved over time, based on observations of student engagement, and reflects on their use in the author’s setting.

4.1 The activities

The following lecture activities have been developed using the audience response tool Mentimeter (https://www.mentimeter.com/), which allows for a variety of polling techniques, including answering multiple choice questions, providing open ended responses, rating statements, and ranking items. Participants join a Mentimeter presentation on their own device and can advance either at the presenter’s pace or at their own pace, based on the settings chosen by the creator. Responses are all anonymous and, as well as the polling options listed above, participants can interact with slides via a range of reactions, for example thumbs up or thumbs down. The author has not explored all polling options but, in this section, outlines the key strategies used in an attempt to promote student engagement whilst teaching around 80 students enrolled on a level 2 maths module for engineering students. The author also notes that the use of the free version of Mentimeter, as with any other audience response tool, has its limitations.

Russell (2022) notes that online polling can create opportunities for instructor-student feedback, which can happen in real time. In a similar vein, online polling allows for formative assessment and adaptive teaching and can provide similar information to the teacher as questioning using mini whiteboards (see section 3.1). In this section, the author also explores the use of Mentimeter to gauge student reactions (see section 3.2) and to assess student confidence and understanding when implementing worked example-problem pairs (see section 3.3).

Perhaps the most obvious mode of interaction, multiple choice questions are a popular tool for checking students' understanding in a lecture. The author has implemented traditional multiple choice questions using Mentimeter to judge students' understanding of mathematical concepts, but has also used multiple choice questions to evaluate students' enjoyment of subjects. For example, figure 1 shows the multiple choice activity used in the first module lecture, in which students were asked to complete the sentence "*Maths is*…". Results from the activity did not directly change lecture delivery but provided the author with a useful sense of students' prior experience and enthusiasm for the subject.

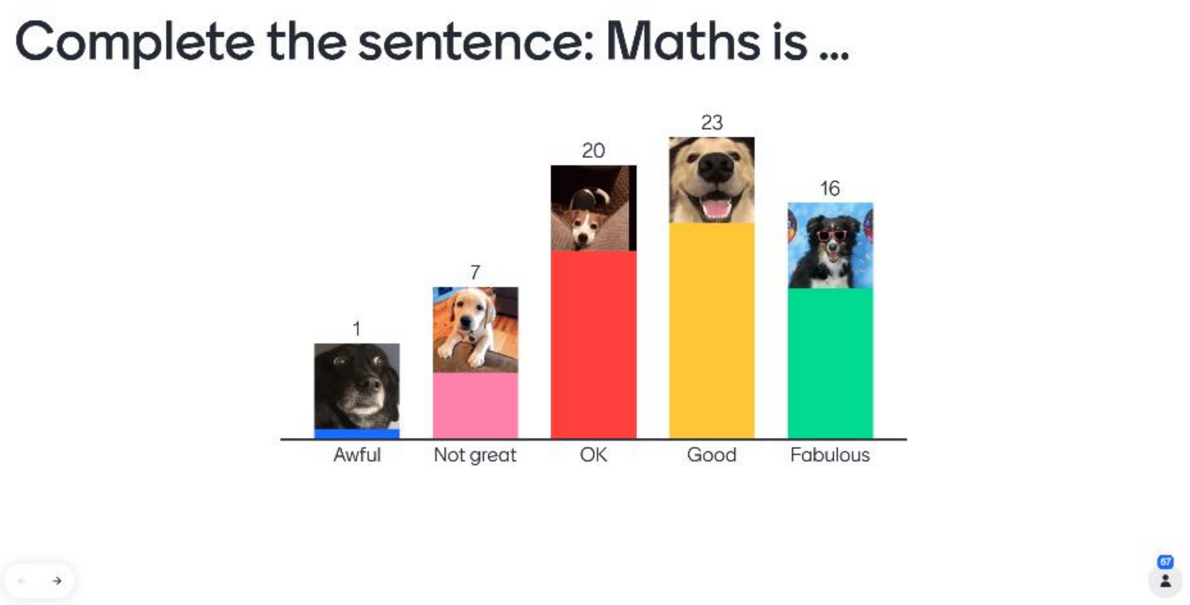

Figure 1. An example of a multiple choice activity created using Mentimeter, used in the introductory lecture to gauge students' feelings towards maths.

The student reactions discussed in section 3.2 have been replicated using Mentimeter's reactions feature, for example students have been asked to react to a slide with a thumb up or a thumb down. This basic feature has proved very useful and has been used in a variety of ways to obtain different information from students. For example, students have been tasked with solving a problem and asked to react to a Mentimeter slide with a thumb up when they have completed the problem or a thumb down if they are unsure where to start. This has created opportunities for adaptive teaching and scaffolding when students react with a thumb down. For example, figure 2 shows the final question from an activity recapping trigonometry, in which students were asked to come up with an expression for $\cos(n\pi)$ in terms of an integer n. The author hoped that students would spot that it alternates between -1 and $+1$ for odd and even values of n, respectively, and start to formulate a mathematical expression for this, i.e. $(-1)^n$. After a few minutes of discussion, several students reacted to the slide with a thumb down, indicating that they were unsure how to approach the problem. The author then scaffolded the problem, sketching the graph of $y = \cos(x)$ and facilitating a class discussion. When such activities have been used, solutions have been displayed or students asked to vote for the answer when most students have indicated that they have completed the task, potentially after scaffolding.

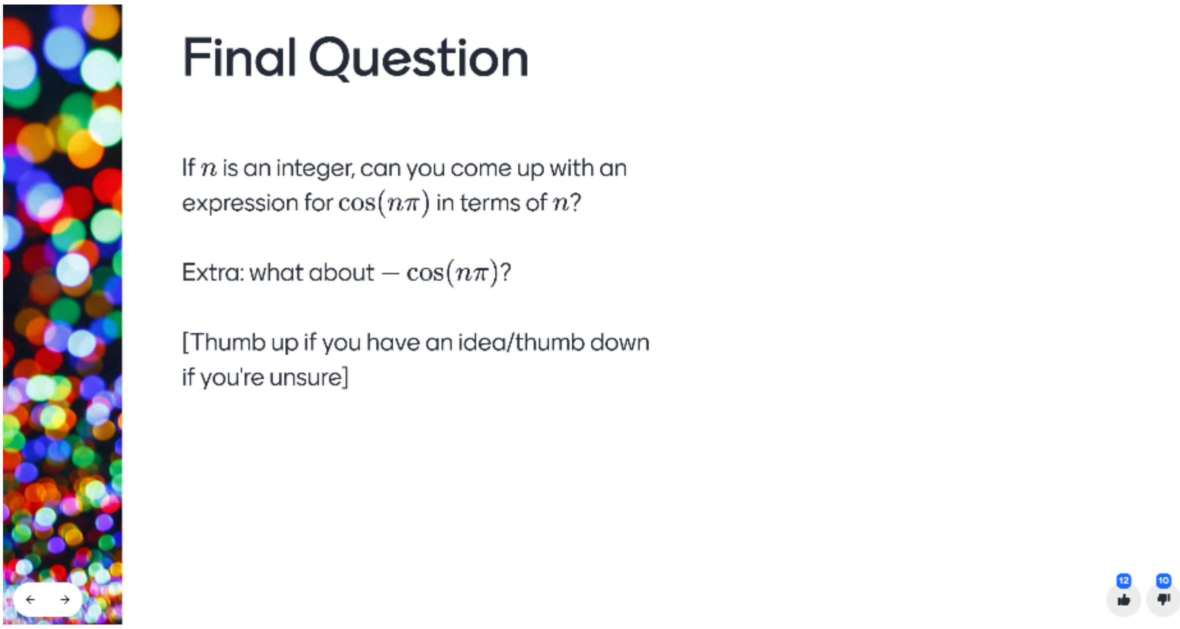

Figure 2. An example of an activity utilising the reactions feature on Mentimeter to gauge students' progress and understanding.

Alternatively, after students have attempted a problem, solutions have been displayed on Mentimeter and students asked to react with a thumb up if they agree with/understand the solution or a thumb down if they disagree with/don't understand it. For example, figure 3 shows the slide following the question displayed in figure 2, in which the solution to the problem was provided. Students reacted positively to this solution slide following the scaffolded class discussion, reassuring the author that the solution was widely understood.

The strategies outlined above have been implemented during worked example-problem pairs: in particular to check students' understanding of the similar problem after attempting it. To gauge students' understanding of the worked example itself, students have also been asked to rate their understanding of a worked example straight after working through it. Similarly, students have been asked to rate their confidence before attempting a similar problem for themselves, after the similar problem has been displayed on the board. Both rating strategies have encouraged adaptive teaching and scaffolding when understanding or confidence have received low ratings.

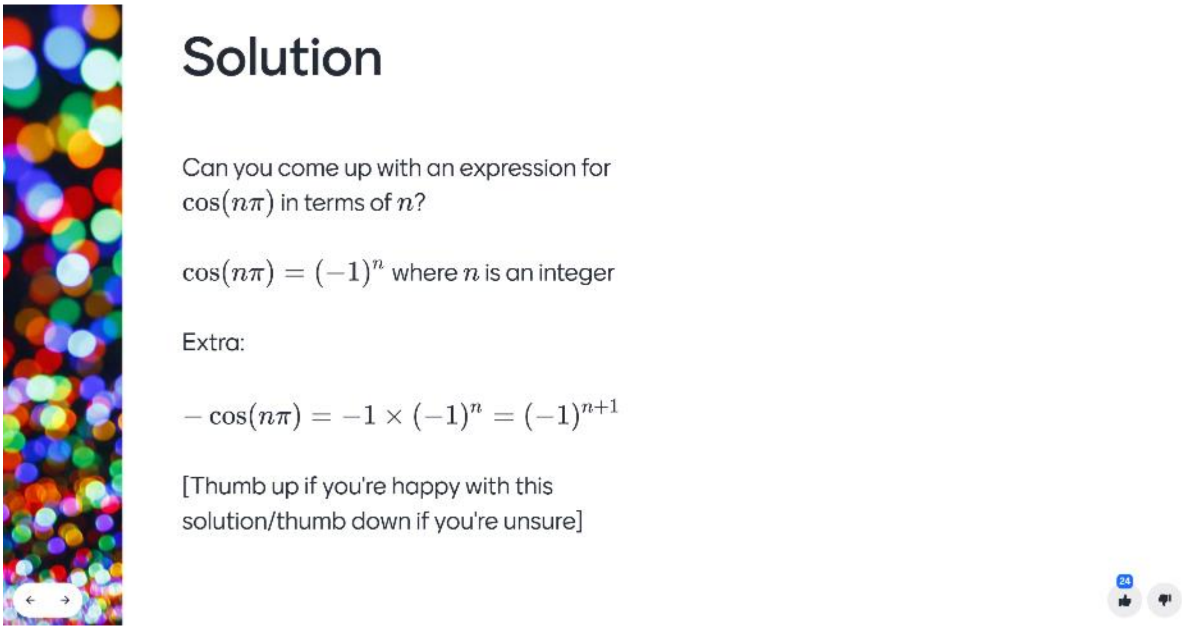

Figure 3. Another example of an activity utilising the reactions feature on Mentimeter to gauge students' understanding. This slide followed on directly from the one displayed in figure 2.

The aforementioned strategies have been used in isolation as quick checks of confidence/understanding, but also combined to create longer activities. In fact, many of the interactive lecture activities used by the author incorporate several of the features discussed above. For example, figures 4-6 display the slides from an activity used in teaching multiple integration. The activity followed a straightforward worked example introducing the topic and started with students rating their confidence before attempting a similar problem. Students then attempted the similar problem, reacting to the second slide to indicate that they had completed it, before voting for the answer on the third slide. The author anticipated fairly high confidence levels and success rates due to the low difficulty of the question and this proved to be a reasonable prediction in this case; if provided with alternative evidence, however, scaffolding would have been provided.

4.2 Adaptations and reflections

The activities outlined in section 4.1 have been updated and adapted over time based on observations of student engagement. For example, early activities provided little in the way of stretch and challenge: students who completed examples quickly sat waiting for their peers to finish and were therefore not engaged for parts of the lecture. As such, extension questions have been included in later activities, where appropriate. For example, figure 7 shows an activity in which a second, more challenging, problem was included for students to try if they worked through the first problem quickly. Longer activities have also been trialled, in which students worked through several questions at their own pace, and reacted to slides along the way to indicate completion/understanding. In accordance with Bloom's taxonomy (Bloom, 1956), these questions were ordered by increasing levels of difficulty, allowing students to access more challenging questions if they worked through the earlier questions quickly, whilst others were able to spend longer getting to grips with the earlier questions. Such activities have been used to ensure that all students are challenged and have resulted in high levels of engagement and motivation. Other adaptations have included the addition of thumbs down to indicate that students are unsure where to start. For example, figure 5, which displays an activity used early in the module, does not include this option whereas figure 2, an activity used later, does. Section

4.1 outlines a specific example in which the thumbs down option included in figure 2 led to scaffolding and adaptive teaching, hence this has been a valuable addition.

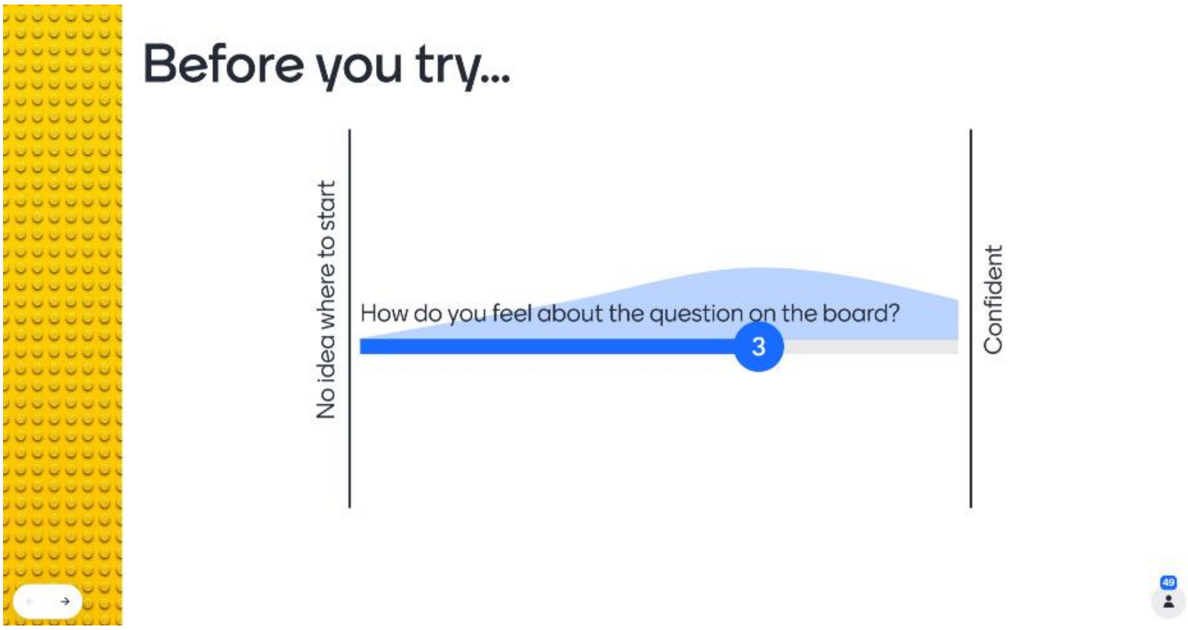

Figure 4. The first slide of an activity combining a range of strategies described in this section, specifically to gauge student confidence before attempting a similar problem, with options 1, 2, 3 and 4 corresponding to statements ‘no idea where to start’, ‘not very confident’, ‘fairly confident’ and ‘confident’, respectively.

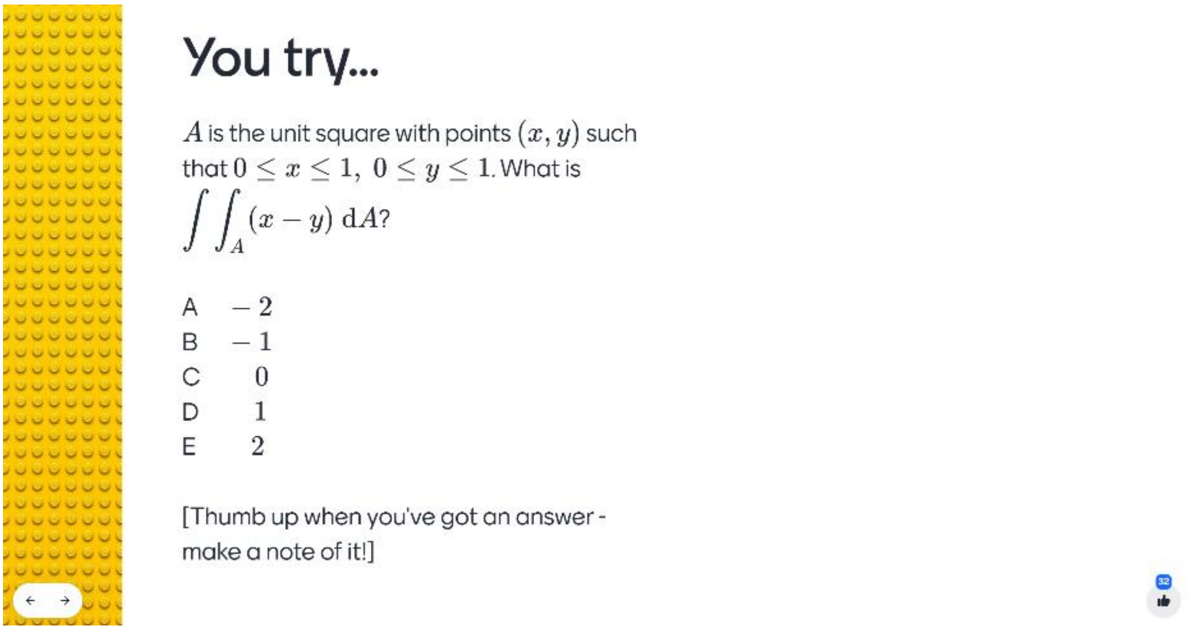

Figure 5. The second slide of an activity combining a range of strategies described in this section, specifically to gauge student progress whilst attempting a similar problem.

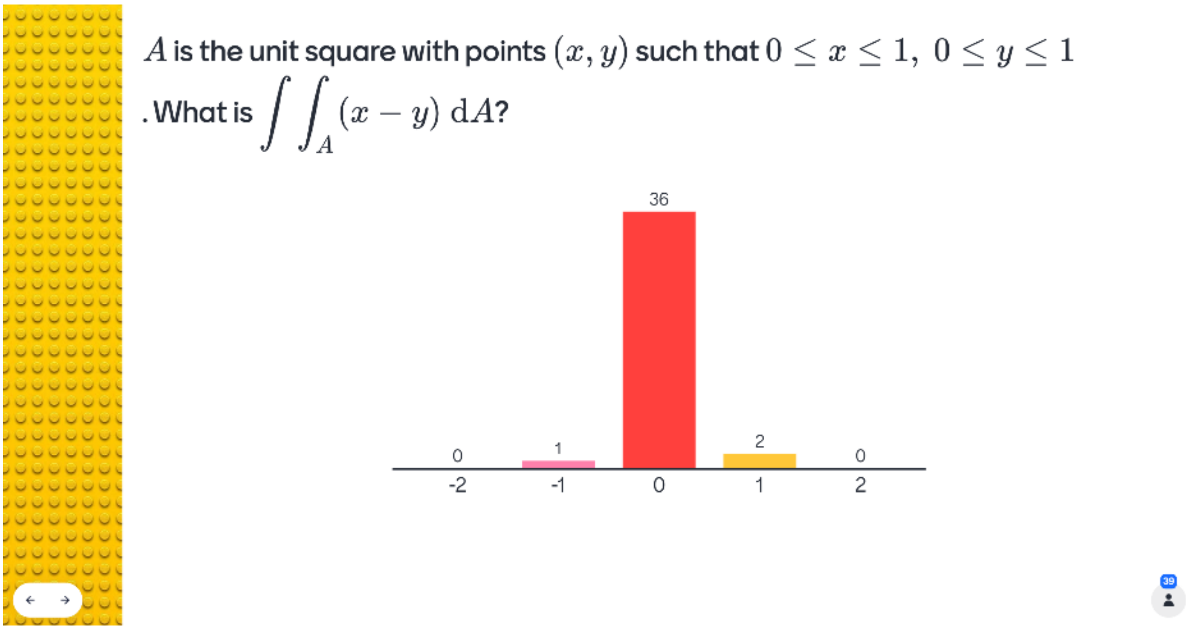

Figure 6. The third slide of an activity combining a range of strategies described in this section, specifically to gauge student understanding after attempting a similar problem.

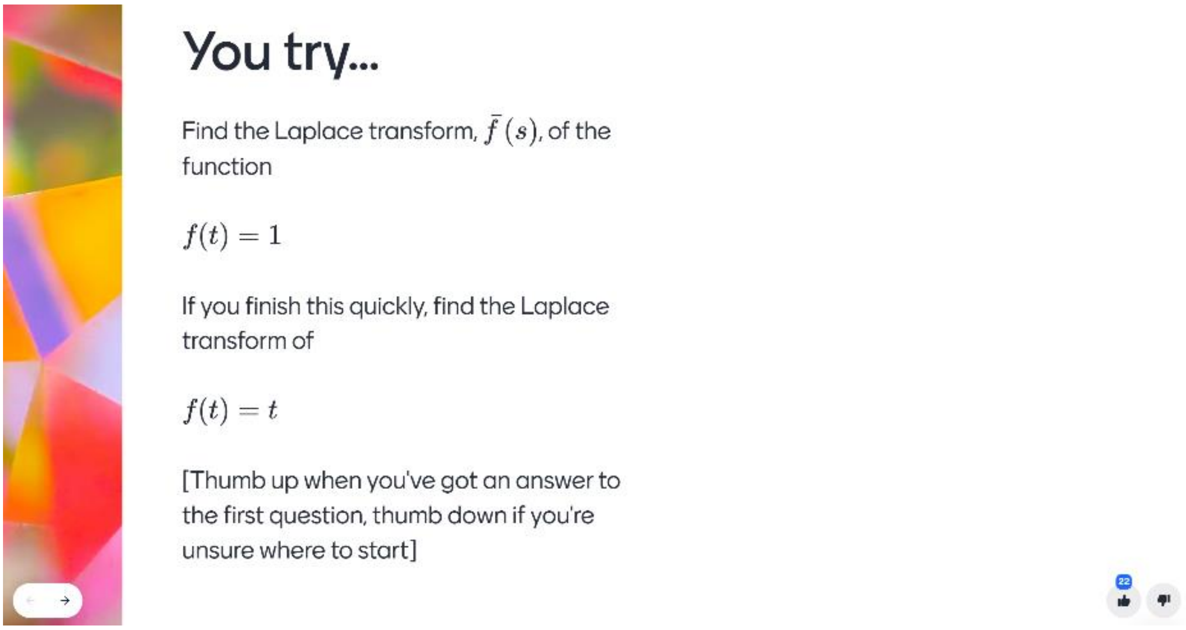

Figure 7. An example of an activity incorporating stretch and challenge via the inclusion of a second, more difficult, problem for those who completed the first problem quickly.

The activities have, in some cases, taken up more lecture time than anticipated and have thus required flexibility from the author. For the module in question, this time has been gained by removing a handful of examples from lectures and instead making them available to students on Moodle. This has worked well in the author's context. Alternatively, a flipped classroom model can be utilised, as described by Russell (2023), for example.

Finally, the activities have not been used to replace real world interactions, but as a tool to promote student engagement and to provide opportunities for formative assessment and adaptive teaching. In the author's experience, they have helped to build trust amongst students and lecturer and have encouraged real world interactions.

5. Conclusion

From the author's perspective, the interactive lecture activities have been successful in engaging students on the module; students have been actively involved in lectures and motivation has been high. The interactive lecture activities have clearly promoted formative assessment and adaptive teaching, and seemingly encouraged student ownership. The activities have been useful for time management and judging the pace of lectures also. Attendance on the module was reasonable, ostensibly better than the previous year, only dropping significantly towards the end of term.

From the students' perspective, the activities detailed in section 4 have generally been well received: specific student feedback is included below.

- "*I really like how interactive the lectures are! This is how all should be in the XXI century*"
- "*I like the interactive aspect, helps to understand the material better*"
- "*I love the interactive lecture :)*"

The module also scored highly in a 'Student Evaluation of Module' survey. The remainder of this article compares the use of activities in the module discussed thus far and a similar engineering module and outlines the author's future plans.

Student participation has been reasonable for the module discussed in this article: the author estimates that at least half of the students in attendance interacted with the activities, often considerably more, but acknowledges that this may not give an accurate representation of student understanding/confidence overall. To the best of the author's knowledge, however, students have reacted honestly, often making use of 'thumbs down' reactions to receive scaffolding. The author believes that the anonymous responses have encouraged this.

However, in a similar level 2 engineering module taught in the following semester, student participation in equivalent activities was much lower and, unlike the module discussed in this article, student buy-in was also low. The author reflects that this may be due to shared teaching on the second module: the lecture activities were introduced to students in the Spring semester after they had bought into another lecturer's teaching methods in the Autumn semester. The author persevered using the activities and highlighted their purpose when participation and engagement were particularly low, after which they did improve, but not to the extent of the original module.

Moving forward, the author aims to develop further strategies to boost student buy-in and incentivise students to engage in activities from the outset. For example, the author plans to explain their purpose at the start of a module and make explicit links to formative assessment and adaptive teaching. The author hopes that this explanation might empower students to engage in activities as a means to take control of their own learning.

In future, the author also aims to develop the activities outlined in this article to facilitate open ended questioning as another mode of formative assessment. Furthermore, the author hopes to adapt other common, engaging classroom activities for use in HE: in particular, collaborative learning strategies such as think-pair-share, group problem solving, and small group discussions. On top of the obstacles outlined in section 3, i.e. student numbers and room sizes, the layout of a standard lecture theatre is also not conducive to collaborative learning. The author hopes to develop strategies to overcome these obstacles, drawing on existing literature and their own teaching experience to formulate activities that successfully promote collaborative learning in their setting. The author is also keen to explore whether activities such as those presented in this article, inspired as they are by classroom practice, might be useful for students transitioning from school to university.

In summary, the author has aspired to re-ignite students' enthusiasm for learning in person and encourage students back to the lecture theatre in a post-pandemic world. The key strategy has been to engage students via interactive lecture activities inspired by common classroom practice, with a particular focus on formative assessment, adaptive teaching, and student ownership. These activities have created regular opportunities for formative assessment to support day-to-day learning and have promoted adaptive teaching based on students' responses: for example, prompting the author to provide scaffolding or to alter the pace of lectures to support students' needs. These features seem to have encouraged student ownership and students have taken a more active role in their learning. Student attendance has also been ostensibly better than the previous year. Overall, the author has been encouraged by the success of the interactive lecture activities introduced in this article and has frequently observed high levels of engagement and motivation amongst students.

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