CASE STUDY

Remote active learning

Ewan Russell, Department of Mathematical Sciences, University of Liverpool, Liverpool, UK.
Email: Ewan.Russell@liverpool.ac.uk

Abstract

Following the necessary shift to online learning in mathematics due to the COVID-19 pandemic, it was widely reported across the sector that encouraging students to engage in online synchronous sessions was very challenging. In this case study, the design and delivery of synchronous sessions for a large Year 1 mathematics module will be discussed. These synchronous sessions utilised an active learning approach which sought to address the difficulties in online learning through a focus on playfulness and games. This approach created opportunities for peer learning and successfully encouraged student engagement and interaction.

Keywords: playful learning, active learning, online engagement, peer learning, polling software.

1. Background

As was the case across the sector, the institution in this case study had to respond to the challenges for mathematics teaching and learning presented by the COVID-19 pandemic. In line with most other institutions, the approach consisted of a mixture of asynchronous material and online synchronous sessions. Departmental guidelines for asynchronous content included expectations for complete lecture notes and/or high-quality video content recorded using tablets and annotation software.

Staff were provided with ideas for the online synchronous sessions, but module leaders were free to design the approach and activities themselves. The only clear expectation was that these sessions should take an active learning approach. It has been reported from the sector, at online workshops such as the Teaching and Learning Mathematics Online (TALMO) events, that engaging students in online environments can be very challenging. One specific issue which was highlighted was that students did not appreciate being moved into small-group breakout rooms against their will (Walkden, 2021). In addition to student engagement and motivation in general, another challenge which was identified was getting a sense of how students are coping with the material (Shaker, 2021; O'Malley et al., 2021). Feedback from Mathematics students at the institution indicated that they did not like online synchronous sessions which were unstructured or were run as drop-ins.

This case study will focus on the design of online synchronous activities for a Year 1, semester two module (115 students) which covers number theory and some initial ideas from group theory. This is a theoretical module, and mostly followed a traditional teaching approach pre-pandemic (a mixture of lectures and tutorials). The module is compulsory for all students on the BSc Mathematics and MMath programmes.

2. Development of the approach

Active learning is often characterised by students' cognitive investment and active participation in learning (Zepke and Leach, 2010). Intrinsic to active learning strategies is student engagement which is often encouraged through peer interactions (Kuh et al., 2006).

The synchronous session design was influenced by findings (both locally and from the wider sector) in semester one of the 2020/21 academic year. Based on experiences in semester one, colleagues flagged engagement as challenging and attendance as low at online synchronous sessions. The majority of online synchronous sessions in semester one attempted to simulate the tutorial environment, encouraging students to work on weekly exercise sheets in small-group breakout rooms. As stated previously, students felt that this approach was unstructured and did not encourage engagement.

After reflecting on experiences from semester one, the author identified specific aims for the online synchronous sessions in the Year 1 module. These were:

- encourage peer discussions
- determine whether students are engaging with the asynchronous resources for the module
- develop students' appreciation of the need for accuracy and clarity in the written presentation of mathematics
- develop students' enthusiasm for the campus and city region where they will be studying in-person in the future.

The final goal was defined in recognition of the fact that most mathematics students had not set foot on campus at all in the academic year due to UK COVID-19 restrictions. The author sought to build students' optimism about the prospect of being on campus in the near future.

It has been documented that a playful learning approach utilising games can foster creativity, encourage student enjoyment of learning, and provide a shared experience in a low-stress environment (Whitton, 2018). Highlighting the creative nature of the discipline can encourage learners to engage with the material as has been noted in several articles on recreational mathematics (e.g., Rowlett et al., 2019; Sumpter, 2015). The "safe space" concept associated with playful learning emphasises that it is acceptable and natural to make mistakes when learning new material, and that exploring or discussing mistakes can be very useful learning activities.

Inherent to the playful learning approach in group work is the encouragement of peer discussions and creating opportunities for students to learn from their peers. One method by which this can be achieved is peer instruction and participation (Crouch and Mazur, 2001). As students are tasked with convincing peers of their arguments, peer instruction has been observed to encourage the development of reasoning and communication skills.

When discussing problems with peers, differences in approach and method can lead to the identification of misconceptions or errors. From this perspective, engaging with peers in discussions has some overlap with learning from errors pedagogy (Tulis et al., 2016; Metcalfe, 2017). Under this pedagogy, errors are discussed openly and utilised as an important learning opportunity:

"Praise (for the correct answer only) curtails discussion and reinforces the teacher role as the authority who bestows rewards" (Tulis et al., 2016).

As encouraging discussion was a key aim of the endeavour, the author decided to adopt elements of learning from errors pedagogy in the approach for one of the games in the synchronous sessions. This was closely aligned with the approach of Groβe and Renkl (2007) primarily because their version does not rely on students making mistakes or errors themselves and subsequently having these picked up by peers (which could be disheartening for some students). Instead, the approach advocated by Groβe and Renkl tasks students with identifying mistakes or errors in worked examples. This approach pushes the learning from errors element further towards a game and a playful learning approach.

The approach adopted in the online synchronous sessions for the module therefore aimed to pursue a playful learning approach incorporating elements of peer learning and learning from errors. The peer instruction method of Crouch and Mazur was adapted to eliminate the initial (individual) vote which is usually included. One of the reasons for this omission is that in the purely online environment there is no way for the lecturer to ensure that any vote is not a collaborative effort. In the new approach, the initial vote will take place following peer discussions. It was hoped that these vote results would help to identify any widespread difficulties with the material. The combination of approaches aimed to provide an active learning environment where students were able to develop their confidence.

3. Structure of the online synchronous sessions

Every module in the Department was allocated a two-hour online synchronous session per week. The playful learning approach for the module in question consisted of three activities (labelled as "rounds") per week. At the beginning of the module, students were allocated to private channels on Microsoft Teams (approximately five students per channel). At the beginning of each round, the challenge was uploaded to the Team in PDF format. Students were then encouraged to move into their private channels to discuss the particular challenge. Student groups were given 20 minutes for each of these discussions. After 20 minutes, the whole class came together again in the main Teams call where anonymous polling was used to collect thoughts and opinions about the challenges. A summary of the three rounds is given in the table below.

Table 1 - breakdown of the three games ("rounds") in the synchronous sessions.

Round	**Focus**	**Format**
1	Revision of main theoretical ideas from asynchronous material for the week	5 or 6 multiple choice questions covering definitions and elementary examples from the weekly material.
2	Presentation of written mathematics related to the weekly material	4 sample answers to typical questions from the weekly material. Each sample answer contains an error. Students are challenged to identify these errors.
3	Consolidation of main ideas from asynchronous material for the week	Students are provided with coordinates in decimal degree format for an attraction in or near to the city. 8 of the digits are missing - students must solve clues relating to the weekly material in order to identify the mystery location. Students must also find out something interesting about the mystery location.

The University has a licence for Poll Everywhere and this was utilised in each of the three rounds to gather student views and encourage engagement. This software has many different formats for polls (including multiple choice, open text response, upvoting and clickable image). This range of polling offers the lecturer the opportunity to diversify the methods by which they invite students to engage. The anonymity feature also encourages student engagement.

3.1 Round 1

The focus of the initial round was on revision of the main ideas from the weekly asynchronous material. For this round, five or six multiple choice questions were designed which tested knowledge of definitions or simple examples from the asynchronous material. In line with recommendations in the pedagogic literature, questions in this round were not too complicated, and were designed with suitable distractors as options. The aim of this approach is to ensure that students cannot determine the correct answer by a process of elimination (King and Robinson, 2019). It is also noted that polling using electronic voting systems such as Poll Everywhere can catalyze active instructor-student feedback in real time. This was certainly a goal of the initial round of activity as the author aimed to determine what students had absorbed from studying the weekly asynchronous resources and highlight any potential issues with core concepts before progressing to subsequent rounds.

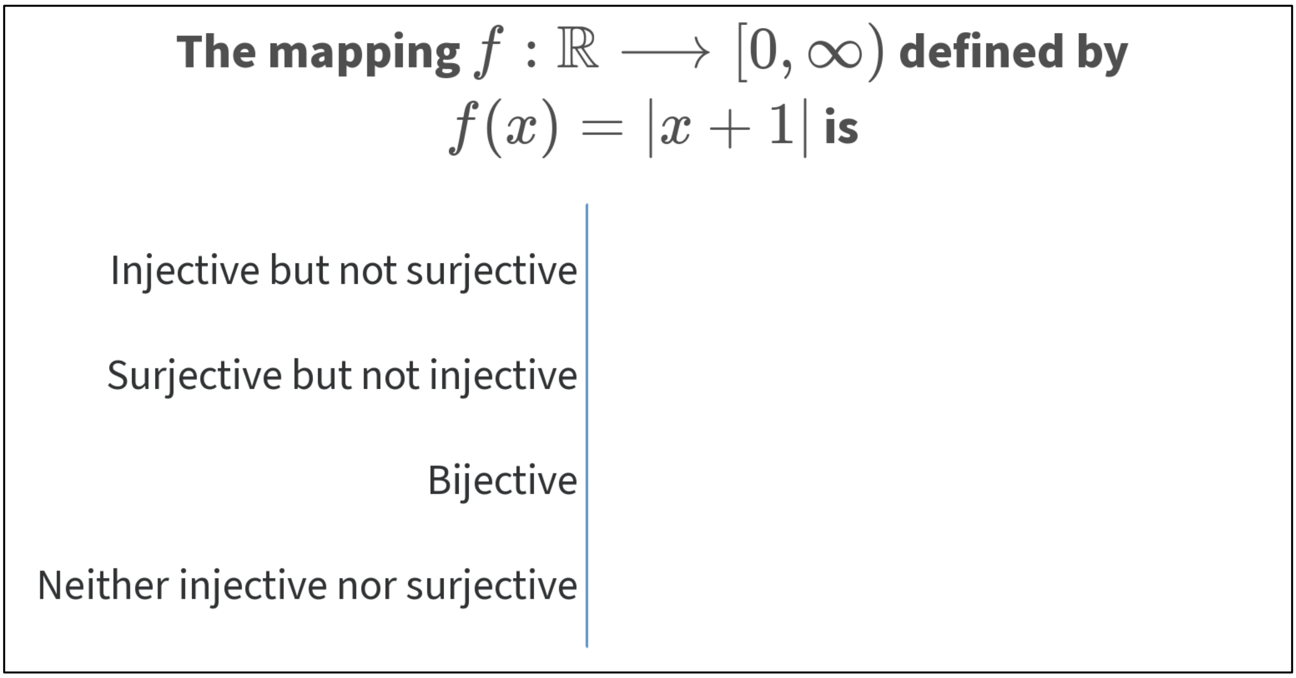

Figure 1. Example of a question in Round 1.

3.2 Round 2

The second round focused on the presentation of written mathematics and learning from errors. Over the years, the author has observed common errors in student submissions and this round was an opportunity to highlight these common errors by presenting sample solutions containing these errors to students for discussion.

As was the case in Round 1, a PDF document with 4 short sample solutions to questions from the recent material was uploaded to the Team. Students were advised that each sample solution contained an error and they were tasked with identifying these errors. Errors could be in terms of presentation (logical argument) or a more fundamental theoretical error in method. Again, students were encouraged to move into their private channels to discuss these sample solutions for 20 minutes (and most students did so). After the private channel discussions, the whole class came together again in the main call and a clickable image poll was conducted on Poll Everywhere. In this poll, the image of each solution was presented and students were asked to drop an anonymous pin on the image where they believed the first error occurs. This poll enabled the lecturer to observe where clusters of pins were grouped. As a follow-up poll, students were asked to elaborate on their pin choice in short text responses. Poll Everywhere then automatically runs a summary of these anonymous comments on the screen for students to view.

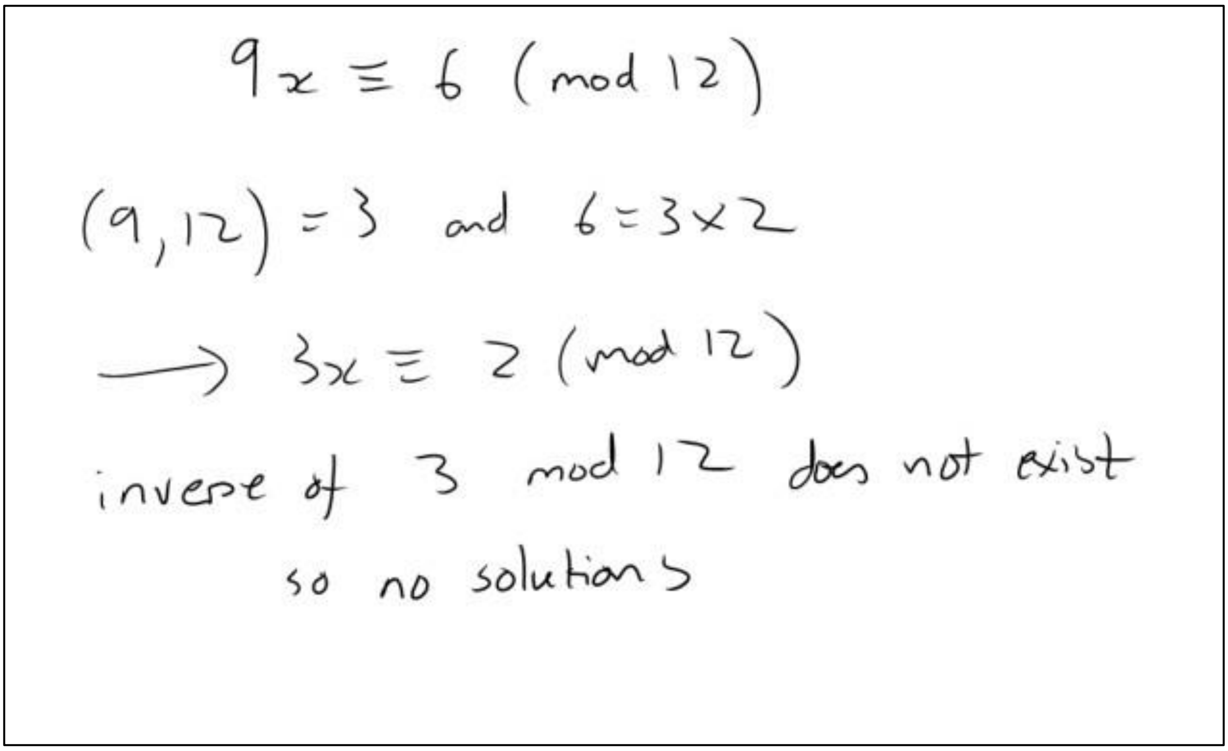

Figure 2. Sample answer with error from Round 2.

The example in Figure 2 is a particularly useful sample answer with error as there are several areas where students might identify an error (in method or in presentation). For example, some students identified the second line "6 = 3 x 2" as a point where an error takes place as the author did not explain why this is relevant in the progress of their solution. Perhaps this would not really be classified as an "error", but this did help to stimulate discussion around the incompleteness of the solution. Another subset of students identified the arrow in line 3 as an error (as many of them believed it would be more properly communicated with an implies sign). The majority of students identified the "12" in line 3 as the main error as the author of the solution did not divide the modulus (12) by the greatest common divisor (3). Each of these subsets of students make a valid point and thus this activity is very useful in discussing the range of errors which can be made, and the need for accuracy when presenting and communicating written mathematics.

3.3 Round 3

The third (and final) round challenged students to work in their groups to find a mystery location in or near to the campus location where they will be studying in-person in future. This challenge was specifically designed to consolidate knowledge from the asynchronous resources for the week in the guise of a game. Coordinates for the mystery location were provided in decimal degrees format. Eight of the digits in the decimal degree representation were missing (labelled as a, b, c, d, w, x, y, z). Students were provided with a PDF document consisting of a set of eight clues (one for each of the missing digits). The clues were not overly stretching and required students to demonstrate their grasp of fundamental topics / concepts from the recent material (see Figure 4). As with the previous challenges, students were encouraged to move into their private channels to work on this challenge, and most did so. Students worked on this challenge for 20 minutes.

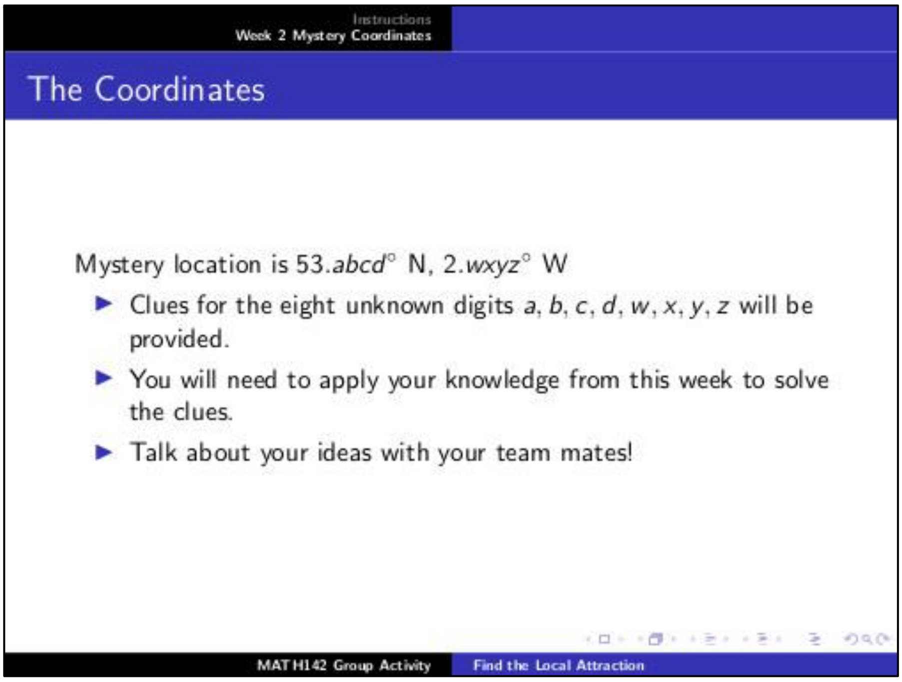

Figure 3. Example instructions for Round 3.

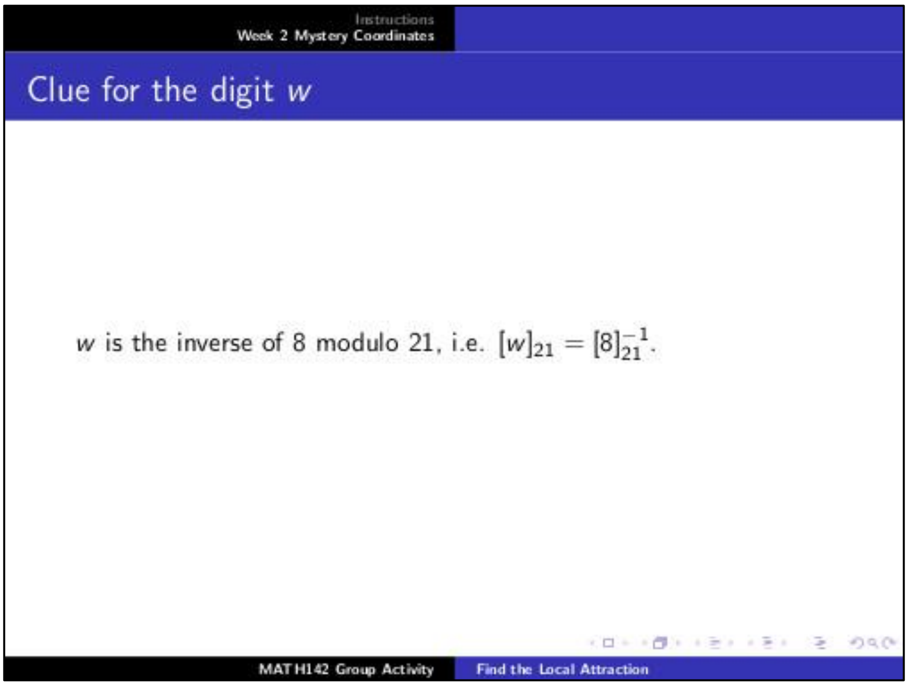

Figure 4. Example clue from Round 3.

When the class came together in the main call, a clickable image poll was run on Poll Everywhere. This time, the image was a map of the local region and students were encouraged to drop an anonymous pin on the image where they believed the mystery location was. Students were then asked to respond to a multiple-choice poll indicating which clue they found the most challenging. Once the correct answers were discussed, students were invited to fill in an open text poll with a fact that they had discovered about the mystery location.

4. Initial feedback and reflections

The online synchronous sessions for the module were well-attended with an average 75% attendance. For comparison, the average online synchronous session attendance across all core semester two Year 1 Mathematics modules was 50%. Students expressed their opinions on the module in a mid-semester survey (response rate 64%). The main results concerning the synchronous sessions are given in Figure 5 below.

Student opinions on the synchronous online activities

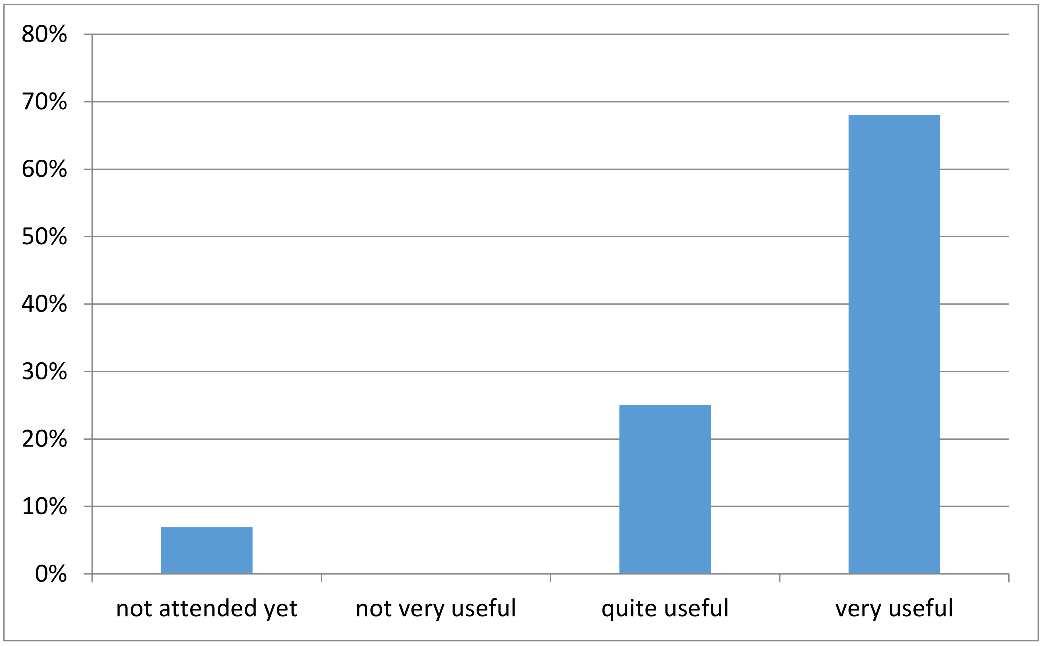

Figure 5. Responses to the survey statement "I have attended the live sessions and the activities are..."

As can be seen from the initial feedback, the synchronous sessions were well-received by students, with nearly 70% of respondents feeling that the activities were "very useful". It should also be noted that all students who attended live sessions and responded to the survey found the activities useful.

Especially encouraging is the fact that several (6) free-text student comments on the sessions described the activities as "engaging" and "interactive" – this was a key aim of the sessions and represents a significant achievement given the struggle across the sector to encourage this interaction in online mathematics sessions.

There are several components of the approach which the lecturer felt contributed to the success of the live session activities. These are given below.

- The challenges and games provided structure to the sessions. This is in contrast to the "any questions?" drop-in format which has been adopted by others to limited success.
- The focus of these sessions was on consolidation of the main ideas / concepts. The answers to clues were often stated clearly in lecture notes or very simple calculations which reinforce the fundamental methods. From this perspective, the challenges were not designed to be daunting for students and could instead be identified as "do-able". The activities were therefore able to act as a confidence-boosting springboard to higher order examples on additional question sheets.
- In contrast with some strategies employed in peer learning studies, students were given time to discuss the challenges with their peers in groups before any polling was conducted. This ensured that the poll results were the consensus view from group discussions and the lecturer was alerted to any widespread difficulties with the material.
- Students were constantly engaged in their work with peers and were not left lingering on one activity for too long. As an active learning strategy, the focus was rightly on what the students were doing and not on what the lecturer was doing.

Inevitably there are some trade-offs with this approach. In creating a safe space for peer discussions, the lecturer is not able to determine whether all students are engaging. While participation in polling and attendance at live sessions are positive indicators, the lecturer cannot be sure that all students in attendance are discussing the challenges with their peers. This would obviously be much easier to determine (and respond to) with in-person classes. There are many opportunities for individual support and feedback in the module via online office hours, exercise sheets etc. The lecturer viewed the synchronous sessions as confidence-building activities to encourage students to tackle the individual tasks and seek out individual support if required. The lecturer felt that the benefits of the approach outweighed the drawbacks, and that creating a safe space for students to develop their confidence in discussing the material was the most important feature of the approach.

5. Future plans – taking the initiative forward post-pandemic

As the sector moves towards a hybrid or blended future post-pandemic, many higher education practitioners are re-evaluating their approach to in-person student learning activities. This is certainly the case at the institution in this case study. As high-quality asynchronous resources have been created during the pandemic, there have been discussions on how best to utilise these and make effective use of in-person classes. For some practitioners (such as the author) this represents an opportunity to free up additional time for active learning and consolidation activities in place of lectures under a flipped classroom model.

The intention for the 2021/22 academic year is to evaluate the success when transferring the successful online model from 2020/21 to an in-person flipped classroom model. Explicitly, the playful learning activities (the three distinct "rounds") will be utilised in the large in-person classes. It is hoped that this will enable the lecturer to observe how students are coping with the activities and to step in when the class appears to be struggling. In the online format from 2020/21, the author deliberately stayed away from the private channel discussions and simply offered to come into the channels if the students made a request. This was intended to create student safe spaces (private channels) where the groups felt free to express their ideas and discuss topics openly. Twenty minutes appeared to be the suitable time for these rounds online, but in-person it should be easier to determine when each round should be brought to a close.

In the 2021/22, a study will be conducted which aims to capture any changes in student confidence when communicating mathematics and working with their peers in these activities. The findings will be reported soon after and it is hoped that data will be collected from several cohorts to determine a sustained impact of the activities.

6. References

Crouch, C.H. and Mazur, E., 2001. Peer Instruction: Ten Years of Experience and Results. *American Journal of Physics*, 69(9), pp.970-977. https://doi.org/10.1119/1.1374249

Groβe, C. and Renkl, A., 2007. Finding and fixing errors in worked examples: Can this foster learning outcomes? *Learning and Instruction*, 17(6), pp. 612-634. https://doi.org/10.1016/j.learninstruc.2007.09.008

King, S. and Robinson, C., 2019. 'Pretty Lights' and Maths! Increasing student engagement and enhancing learning through the use of electronic voting systems. *Computers & Education*, 53(1), pp.189-199. https://doi.org/10.1016/j.compedu.2009.01.012

Kuh, G., Kinzie, J., Buckley J. et al., 2006. What matters to student success: A review of the literature. Available at: https://nces.ed.gov/npec/pdf/kuh_team_report.pdf [Accessed 20 October 2021].

Metcalfe, J., 2017. Learning from errors. *Annual Review of Psychology*, 68, pp.465-489. https://doi.org/10.1146/annurev-psych-010416-044022

O'Malley, J., O'Neill, R. and O'Hanrahan, P., 2021. Transitioning study groups online to Microsoft Teams. Student Engagement and Interaction, TALMO workshop. Available at: http://talmo.uk/slides/OMalley.pdf [Accessed 13 October 2021].

Rowlett, P., Smith, E., Corner, A., O'Sullivan, D. and Waldock, J., 2019. The potential of recreational mathematics to support the development of mathematical learning. *International Journal of Mathematical Education in Science and Technology*, 50(7), pp.972-986. https://doi.org/10.1080/0020739X.2019.1657596

Shaker, A., 2021. Adapting to online teaching at short notice: Classroom polling and other forms of student engagement. Student Engagement and Interaction, TALMO workshop. Available at: http://talmo.uk/slides/Shaker.pdf [Accessed 13 October 2021].

Sumpter, L., 2015. Recreational Mathematics - Only For Fun? *Journal of Humanistic Mathematics*, 5(1), pp.121-138. https://doi.org/10.5642/jhummath.201501.07

Tulis, M., Steuer, G. and Dresel, M., 2016. Learning from errors: A model of individual processes. *Frontline Learning Research*, 4(2), pp. 12-26. https://doi.org/10.14786/flr.v4i2.168

Walkden, C., 2021. Encouraging student interaction in online tutorials, Tackling Term 2: top tips from Term 1, TALMO workshop. Available at: http://talmo.uk/slides/walkden.pdf [Accessed 13 October 2021].

Whitton, N., 2018. Playful learning: tools, techniques and tactics. *Research in Learning Technology,* 26, 2035. http://doi.org/10.25304/rlt.v26.2035

Zepke, N. and Leach, L., 2010. Improving student engagement: Ten proposals for action. *Active Learning in Higher Education,* 11(3), pp.167-177. https://doi.org/10.1177/1469787410379680