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Students' Perceptions of and Engagement with Asynchronous Active Learning Activities for Developing their Understanding.

CAROLINE M ANDERSON AND BEVERLEY J ALLAN
University of Nottingham

Active learning (AL) engages students in the process of learning and emphasises higher order thinking. During the pandemic, AL activities known as 'application challenges' were interspersed among the content-based activities that were released on a weekly basis, but which Science foundation year students completed asynchronyously. Students' anonymous responses to the application challenges were discussed during live online seminars and formative feedback was provided. End of year module evaluations in both Biology (n = 14) and Chemistry (n = 21) indicated that most respondents either agreed or strongly agreed that completing application challenges (93% and 86% respectively) and receiving feedback on student answers (86% and 76% respectively) helped them to develop their understanding. However, analysis of student engagement in the Chemistry module suggests AL activities, including application challenges, were accessed significantly less than content-based activities. Moreover, on average only 21% students submitted anonymous responses to application challenges even though an average of 56% accessed them. Since application challenges appear to provide a valuable means of developing students' understanding through the promotion of deep approaches to learning, the asynchronous lecture engagement activities will be restructured in an attempt to improve student engagement with the application challenges.

Introduction

Active learning (AL) is an approach which encourages students to be active participants, promotes learning processes, and facilitates the development of higher order thinking skills (Freeman *et al*., 2014). AL encompasses a broad range of activities, including setting problems which students complete individually or in groups, providing opportunities for students and tutors to ask and answer questions, and encouraging students to share their ideas during discussions. A meta-analysis conducted by Freeman *et al*. (2014) found that incorporating AL activities into undergraduate science, technology, engineering, and mathematics classes improved student performance in assessments by an average of 6% compared to expositioncentred lecturing approaches. They further concluded that AL is particularly beneficial for classes of 50 students or fewer. These findings are of interest because the cohort size of the Science with Foundation Year course (known hereafter as the Science FY) at the University of Nottingham typically varies between 35 and 45 students. The Science FY prepares students for undergraduate degrees in the biological and healthcare sciences and comprises four, year-long compulsory modules: Foundation Biological Sciences (known hereafter as 'Biology'), Foundation Chemistry ('Chemistry'), Maths for Foundation Science and Studying Science.

The decision to switch to asynchronous use of AL activities on the Science FY course was necessitated by the move to online delivery during the Covid-19 pandemic. In previous years, AL activities had been incorporated into in-person lectures through the inclusion of short quizzes and 'think, pair, share' (Felder and Brent, 2003) discussion activities. In-person workshops and tutorials provided further opportunities for students to ask and answer questions, carry out calculations, work on problems and engage in discussion. In response to the restrictions imposed by the pandemic, it proved necessary to embed AL activities within the asynchronous lecture engagement sessions which replaced live, in-person lectures. A typical week involved the release of asynchronous lecture engagement material which addressed the content in the form of narrated PowerPoints, online videos, Moodle lessons and reading tasks. Students were also set a range of AL activities to complete, such as answering online quizzes, creating summary tables or flow charts, and completing 'Pause and Test' questions within the PowerPoint recordings.

The asynchronous use of AL activities remains an under-researched area (Freeman *et al.*, 2014). A short paper by Koppelman (2009) provided some guidance about how to adapt AL for asynchronous distance education, but it did not assess whether students engaged in the AL activities or benefitted from them. This paper offers insights into whether Science FY students at University of Nottingham perceive that they have benefitted from asynchronous AL activities by describing findings from end-of-year module evaluations for the Biology and Chemistry modules. It also compares, for the Chemistry module, students' engagement with asynchronous AL activities to their engagement with activities which used an expository approach to the delivery of content material.

Application Challenges

One of the AL activities was labelled as an 'application challenge'. This type of activity required students to apply concepts and ideas covered within the content-based engagement material to novel situations. Some of these activities were near-transfer tasks, where students related what they had learnt when completing the lecture engagement activities to different examples (Leberman and McDonald, 2016). For instance, during week 8 of the lecture engagement activities for the Biology module, students were taught how to use the Chi-squared (χ^2) test to assess whether the observed results of a genetic cross involving pea plants were statistically significantly different from the expected outcomes. That week's application challenge required students to use the χ^2 test to assess whether the proportions of the UK population with different blood types (O, A, B and AB) are statistically significantly different from those expected from genetic crosses between people with different blood types.

Many of the application challenges aimed to encourage students to develop their understanding of the content material by promoting a deep approach to learning (Marton and Säljö, 1976). Students who adopt a deep approach to learning seek to understand the underlying concepts and actively make connections between new information and prior knowledge. Application challenges promoted a deep approach to learning when they required students to relate information from different parts of a topic to each other in order to provide a comprehensive response to the question asked. For example, in week 4 of the Biology module, the application challenge required students to explain why some biological molecules cannot pass directly through the plasma membranes which surround cells and are instead exchanged using specialised protein molecules known as co-transporters. To answer this question, students needed to relate what they had learnt about the chemical structure of biological molecules during weeks 2 and 3 of the Biology module to what they had learnt during week 4 about the biochemical components of the plasma membrane and the mechanisms of exchange across the plasma membrane.

Student Responses

Students were encouraged to submit their responses to the application challenges anonymously using a student response system (SRS) such as Padlet or Slido. Students' responses were then used as the basis of discussion in synchronous online seminars where common errors and misconceptions were addressed, and guidance was given about what was required to construct a correct response. Students' responses also provided course tutors with an invaluable opportunity to gauge students' level of understanding. A typical weekly outline for the modules is illustrated in figure 1.

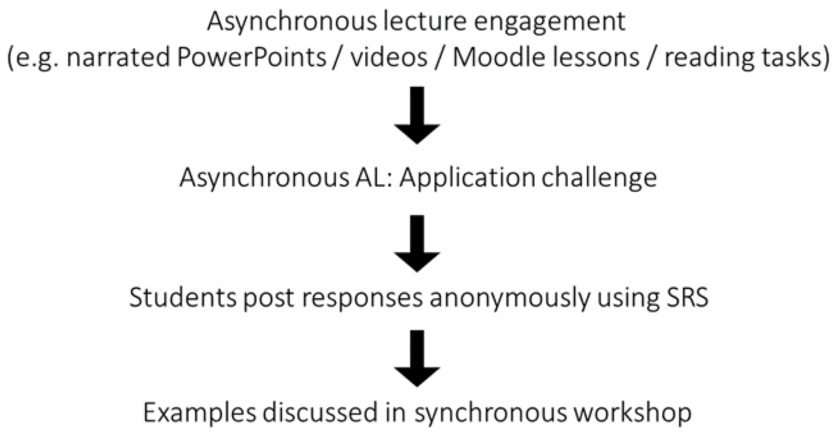

Figure 1: The structure of a typical week for students where AL = active learning and SRS = Student Response Systems (e.g., Padlet and Slido).

Asking students to post their responses using student response systems allowed feedback to be delivered in different ways. The most common of these was for the lecturer to talk through students' responses during a live workshop session, highlighting good examples and drawing attention to common errors, as well as explaining how content covered within the lecture engagement materials could be used to provide accurate, concise explanations for the novel situations described within the application challenge. As students became more familiar with the application challenges and what was required to answer them correctly, they were sometimes encouraged to informally evaluate each other's responses and provide constructive formative feedback about how the responses could be improved.

Student Feedback on Application Challenges

As part of the Student Evaluation of the Module (SEM) survey process carried out at University of Nottingham, students were asked to rate the impact of the application challenge activities, and the subsequent formative feedback provided, on their understanding. The SEM is a Likert-style survey (Likert, 1932) where students are asked to rate several statements using strongly agree (SA), agree (A), neutral (N), disagree (D) or strongly disagree (SD). Seven of the statements on the SEM survey are set centrally by the university but module convenors can add additional questions to evaluate unique aspects of their module. For the Biology and Chemistry modules, two statements relating to the impact of the application challenge activities were added to the SEM surveys. These statements were: (a) *The chance to answer application challenge questions helped in developing my understanding of the topic*, and (b) *The feedback provided on student work submitted in the application challenge questions helped me develop my understanding of the topic*.

Figure 2 provides the feedback obtained in response to the application challenge statements for both the Biology and Chemistry modules. None of the respondents disagreed or strongly disagreed with the statements, with the majority agreeing or strongly agreeing with both statements for both modules (93% and 86% for statement (a) and 86% and 76% for statement (b) for Biology and Chemistry respectively). Only a minority selected the neutral response (14% for Biology; 24% for Chemistry).

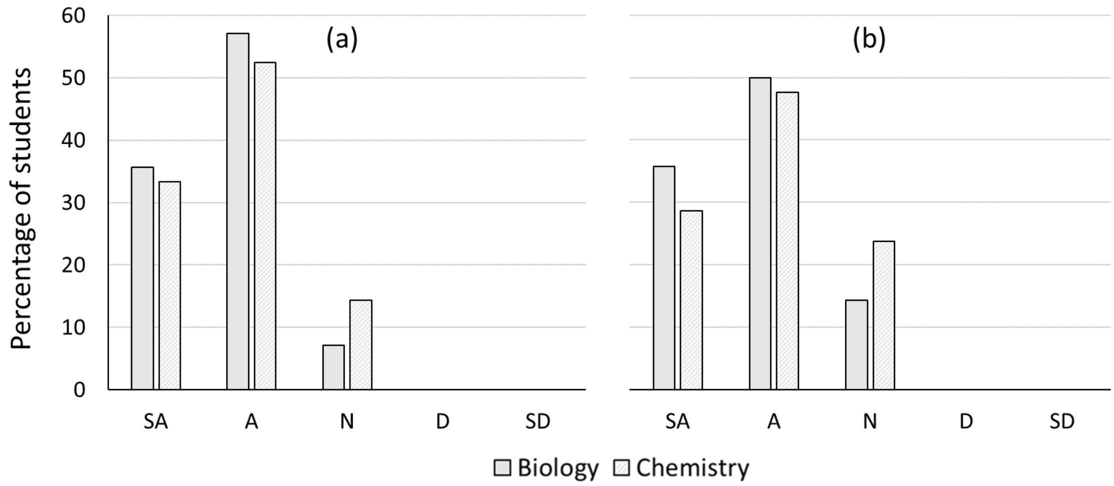

Figure 2: Student responses from the module feedback survey where SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, and SD = Strongly Disagree. (a) Illustrates the responses to the statement, *The chance to answer application challenge questions helped in developing my understanding of the topic* and (b) illustrates the responses to the statement, *The feedback provided on student work submitted in the application challenge questions helped me develop my understanding of the topic*. Response rates for Biology and Chemistry were 41% (n = 14) and 62% (n = 21) of the cohort, respectively.

In addition to providing ratings for each of the statements, students were invited to add open text comments, though they were not required to do so. Very few students added open text comments, but there were two which related to the application challenges activities and the formative feedback provided during the workshops:

> "The activities … got me thinking and gave me an idea of my understanding of the topics."
> "It was nice seeing the thought process of lecturers and seeing where I was going wrong."

Student Engagement and Responses

For the Chemistry module, the asynchronous activities were set out each week on the Moodle learning platform in a format where an activity had to be completed before the next activity/ activities would be released. This format enabled activity completion data to be extracted for the module. This information, however, only correlates to actual completion of an activity if the activity is a Moodle lesson or quiz which had to be completed to receive a grade. For all other activities, such as narrated PowerPoints, videos or other documents, the data only corresponds to the file being accessed and not necessarily completed. Therefore, the activity completion data in this paper is referred to as activity access.

Figure 3 shows the percentage of different types of activities accessed by the students: (a) the asynchronous content materials including narrated PowerPoints, videos and Moodle lessons; and (b) all AL activities including Moodle quizzes, Rogo formative assessments and application challenges. The mean percentage of content material accessed is 84% compared to a mean of 57% for the AL activities. A dependent group pairwise analysis of access to the two types of activity indicates that a student is indeed more likely to access the content-based material than the AL activities ($p = 0.000$). A Cohen's d_z value of 1.333 suggests a large effect (Cohen, 1988) and corresponds to a 91% likelihood that a student will access more content-based material than AL activities (Lakens, 2013). Therefore, despite students agreeing that AL activities helped them developing their understanding (figure 1), the average level of engagement with active learning activities is significantly lower than the average level of engagement with the content-based materials.

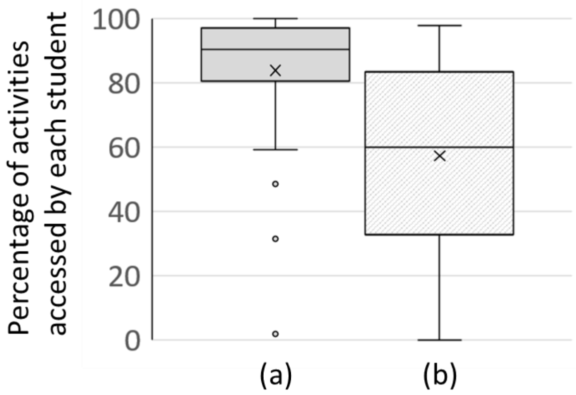

Figure 3: Box plots illustrating the percentage of activities accessed by each student on the Chemistry module (data obtained through the activity completion data on the Moodle learning platform). The cross in each box denotes the mean value which is 84% for (a) and 57% for (b). (a) Access to the asynchronous content materials including narrated PowerPoints, videos and Moodle lessons. (b) Access to all active learning activities including Moodle quizzes, Rogo formative assessments and the application challenges. A dependent group pairwise analysis results in $p = 0.000$ and Cohen's $d_z = 1.333$ ($n = 34$).

The application challenge activities for the Chemistry module, which were used in 11 topics, required students to post responses to the challenge question via Padlet. For these application challenges, the mean percentage of activities accessed by students was 56% (equivalent to 6 out of the 11 activities), which is in line with all AL activities as illustrated in figure 3. Figure 4 shows the percentage of the cohort that accessed each of the application challenge activities compared to the percentage of the cohort that posted a response to the application challenges. The percentage of students who posted responses (mean = 21%) is much lower than the percentage of students who accessed the challenge activity (mean = 56%). For example, in the first application challenge (shown in figure 5 as Activity 1), students were asked to answer two questions. Out of the cohort of 34 students, only 10 students posted answers to the first question and 13 students posted answers to the other. This was one of the activities with the highest response rate (see figure 5, Activity 1).

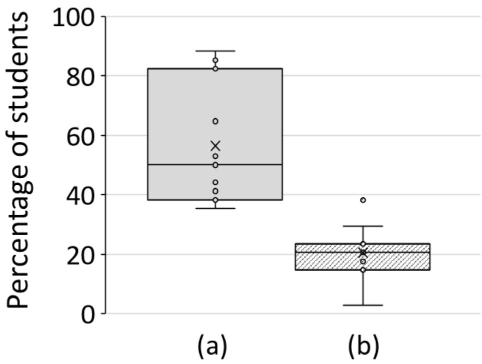

Figure 4: Box plots illustrating the percentage of students (a) accessing the Padlet response application challenge activities and (b) posting a response to the application challenge on the Padlet wall. The cross in each box denotes a mean value of 56% for (a) and 21% for (b) from a cohort of 34 students.

Figure 5 illustrates the percentage of students accessing each of the Padlet activity challenges along with the percentage of students posting a response. It is, of course, possible that those accessing the material may have completed the activity but chose not to share their answer. These students will, however, have missed out on receiving formative feedback on their responses during the live workshop sessions.

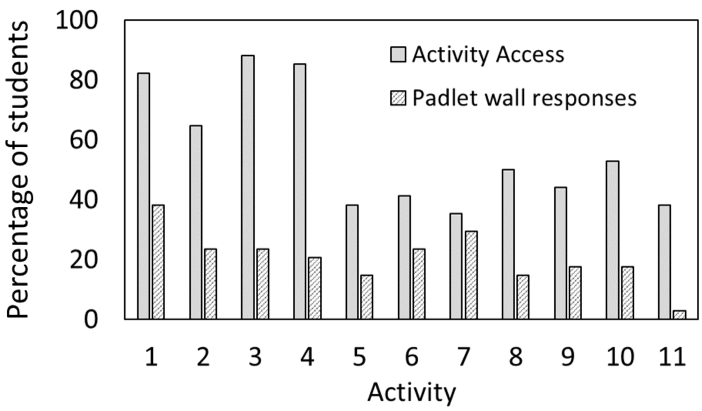

Figure 5: The percentage of students accessing and posting a response for each of the Padlet response application challenge activities.

Conclusions and Future Directions

Science FY students provided very positive feedback about the perceived usefulness of asynchronous AL activities in developing their understanding. Furthermore, student responses proved to be very useful to the course tutors in enabling them to gauge how well students had understood the content covered in asynchronous lecture engagement sessions and identify any common misconceptions or confusion that could be addressed in live synchronous workshops and seminars.

However, although most students agreed that completing the application challenge activities and receiving the subsequent feedback helped them to develop their understanding of the topic, the number of students accessing the application challenge activities was significantly lower than those accessing the content-based materials, such as online videos, narrated PowerPoints and Moodle lessons. These findings highlight the need to structure the blended approach in a way that encourages students to engage with the application challenge activities to the same level as the content-based material. Consequently, in future years, the order in which activities are presented to students will be changed to foreground the application challenge, as illustrated in figure 6. By encouraging students to engage with the application challenge at the start of the session, it is hoped that they will think about how they can apply the concepts and ideas covered in content-based materials to the situation described in the application challenge. Shifting the application challenge to be the focus of the session should facilitate the adoption of a deep approach to learning (Marton and Säljö, 1976), as students will be guided towards developing their understanding of the core principles and urged to make links between different ideas as they progress through the content-based material. Students will be reminded of the application challenge later in the session and encouraged to post anonymous responses, either asynchronously or whilst in a live session, which will then be used in further discussion where formative feedback can be provided to help develop their understanding.

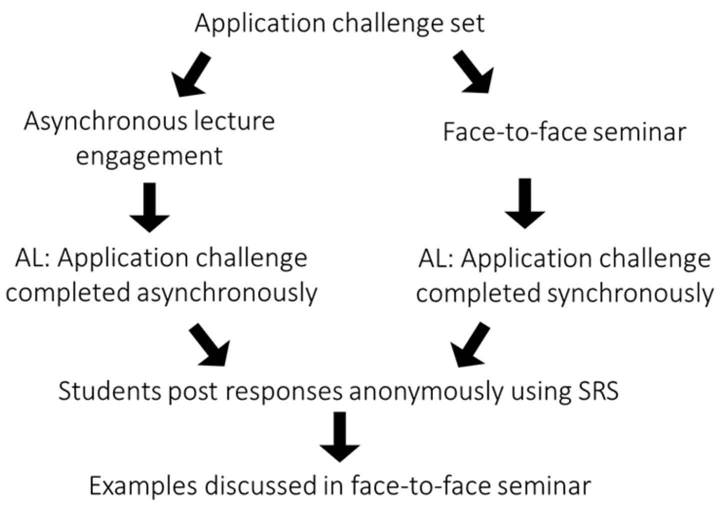

Figure 6: The structure of a proposed typical week for students where ASR = Active Student Response activities and SRS = Student Response Systems (e.g., Padlet and Slido).

In addition to the tutor-led and student-led feedback described earlier in this paper, two further approaches to engaging students with each other's responses will also be trialled. The first of these involves providing students with marking criteria and asking them to assess example responses against these criteria and provide feedback about the mark awarded. The second involves students ranking sets of responses and providing justification for their rank order. Both approaches can be done by students working individually or by students working in small groups.

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About the Authors

Caroline Anderson completed her PGCE in 1998 and began a fifteen-year teaching career in secondary schools. In 2013, she joined the University of Nottingham and is currently Co-Course Director for Foundation Science, convening modules on 'Foundation Biological Sciences' and 'Studying Science at University' (www.nottingham.ac.uk/ foundationscience). She began a Professional Doctorate in Education on a part-time basis in October 2014 and is currently writing her thesis. Her research interests include students' beliefs about knowing, multiple document comprehension, argumentation, assessment, feedback, and reflective practice.

Beverley Allan completed her PGCE in 2004 after a brief career in atmospheric chemistry research, and since then has been involved in learning and teaching in secondary, further and higher education, acquiring over fifteen years of teaching experience. In HE she has convened modules on undergraduate and MSc courses and is currently Co-Course Director for Foundation Science at the University of Nottingham, convening modules on 'Foundation Chemistry' and 'Maths for Foundation Science' (www.nottingham.ac.uk/ foundationscience). Her interests are in the effectiveness of student response systems (https://eic.rsc.org/ideas/ responsive-teaching/3007116.article) and active student response, the impact of flipped learning on attainment (https://jfyn.co.uk/index.php/ukfyn/article/view/14/14), and student engagement with feedback (https://www.cambridgescholars.com/product/978-1-5275-6015-4).

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