CASE STUDY

Improving engagement in large undergraduate statistics tutorial classes

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Abstract

We investigate whether introducing the mobile polling system Poll Everywhere had a positive impact on student engagement in large tutorial classes of a second year undergraduate statistics module. In particular, a short quiz facilitated by Poll Everywhere was introduced at the beginning of the tutorial in order to promote active participation. Students' perceptions of the Poll Everywhere quiz on their tutorial engagement and learning are also explored. We conclude that the Poll Everywhere quiz seemed to have improved student engagement in tutorials and that students believed that it made tutorials engaging and was useful for their learning.

Keywords: student engagement, mathematics tutorials, large classes, Poll Everywhere.

1. Introduction

For the past few years, the student population in the Department of Mathematical Sciences at a UK university has been growing. This is mainly due to 2+2 programme with a partner university in China where students attend Year 0 and 1 at the Chinese university and Year 2 and 3 at the UK university. More than 400 Chinese students join the mathematics cohort in the second year and thus most Year 2 and Year 3 modules at the UK university typically have 300 to 550 students. It is very challenging to engage with such large cohorts, in particular to actively interact with large numbers of students during tutorial classes. Student engagement in tutorials is generally low across the department and so it is vital to look for new and innovative ways to engage students in these classes, while adhering to University's pedagogical philosophy, such as active learning.

The module in this study is a second-year statistics module which is compulsory on the biggest programme in the department and optional on all other programmes. At the time of the study, the module comprised of 541 students, of which approximately 83% of class were students from the Chinese university. The weekly delivery of the module consisted of three hours of lectures and one hour of tutorial classes. Tutorial classes were split into three groups which meant that there were approximately 180 students allocated to each group. Each tutorial group is supported by a member of staff and 7 to 9 tutors.

There are two types of tutorial classes in this module: computer classes and 'standard' tutorial classes. In computer classes, students learn to operate statistical software by solving practical problems on a tutorial sheet. In 'standard' tutorial classes, students solve problems 'by hand' and some questions on the tutorial sheet are related to theoretical concepts. In both types of classes, students are required to work on problems themselves or with their peers, and ask the member of staff or tutor for help if needed. No material is presented on the board. Students are encouraged to attempt questions in advance of tutorials, however it seems that very few students do so. This tutorial model is similar to workshop tutorials discussed by Sharma, Mendez, and O'Byrne (2005) and Shearman, Rylands, and Coady (2012), however with much larger class sizes.

Over the years, the following trend in tutorial participation was observed:

- Computer classes are usually well attended. There are usually around 180 students assigned to a group and average attendance is roughly 50%. This may be attributed to the assessment

strategy, since statistical software is required to complete the module assessment and so students are more likely to attend these sessions (Oldfield, et al., 2018; 2019).
- 'Standard' tutorials are usually poorly attended. There are usually around 180 students assigned to a tutorial group and average attendance is roughly 25%. However, students attending these tutorials engage very well by working on problems and asking questions about problems and/or course content. In many cases, deep and high quality learning is demonstrated.

It seems that less able students who would benefit most from 'standard' tutorials do not attend. Sharma, Mendez, and O'Byrne (2005) concluded that less able students who attended student-centred tutorials performed, on average, better in the exam than those who did not attend. Since it seems that increased tutorial engagement could lead to improved learning outcomes, it is important to encourage student engagement in tutorials, which is the goal of our intervention.

Disengagement in tutorials is quite common across the department. Although the causes for non-attendance of 'standard' tutorials have not been formally investigated, the following may be possible contributors:

- Tutorial attendance is not compulsory and not monitored. Massingham and Herrington (2006) concluded that lack of interest or motivation are great contributors to missing non-compulsory classes. Burke, Mac an Bhaird, and O'Shea (2013) provided evidence that a scheme to monitor attendance improved tutorial attendance. However, the authors did not consider the quality of engagement and it is unclear whether students present engaged actively or just came for the sake of monitoring. Attendance is a commonly used measure of engagement, however it does not necessarily account for the quality of engagement (Beer, Clark, and Jones, 2010). There are nevertheless many studies showing that attendance policies contribute to increased attendance, and this in turn may improve student performance (Moores, Birdi, and Higson, 2019).

- Lifestyle factors (e.g. students having to work) were also identified as reasons to non-attendance (Massingham and Herrington, 2006).

- 'Standard' tutorials are not directly relevant to summative assessment. As discussed by Massingham and Herrington (2006) and Oldfield, et al. (2018; 2019), students attend classes to gain information required for assessment tasks or exams.

- Solutions to tutorial sheets are available on the VLE after the tutorials. As indicated by Massingham and Herrington (2006) and Moores, Birdi, and Higson (2019), availability of resources may influence student attendance.

- Tutorial groups are too large. Oldfield, et al. (2019) reported that the class size has an effect on attendance. In large classes, student absence is not noticed by a tutor and there are no consequences. Students feel anonymous and the sense of belonging is missing.

- A learning space is not suitable. The 'standard' tutorials were conducted in large lecture theatres with tiered fixed seating. This environment does not promote collaborative learning and there is no easy access to all students. As evidenced by McArthur (2015), the learning space plays a significant role in student engagement and learning. Parsons (2017) also confirmed that active learning spaces (room with round tables) promote interactive learning.

Due to tight budgets and lack of suitable facilities and resources, it is not possible to address the majority of possible causes discussed above. Despite the limitations, a time and cost effective solution to address low levels of engagement in 'standard' tutorial classes is proposed and evaluated in this study. The study took place in the academic year 2019/2020.

2. Review of Relevant Literature

2.1. Student engagement

Student engagement is widely discussed and researched, yet no single definition of student engagement has been agreed. For example, Baron and Corbin (2012) point out multiple different definitions and meanings given in the literature. Kahu (2013) considers student engagement as a complex process and suggests a conceptual framework including institutional and personal factors that influence student engagement and consequences of student engagement. Despite the complexity of this topic, according to Beer, Clark, and Jones (2010), engagement seems to be a combination of several different aspects including active and collaborative learning, participation, communication among students and academic staff, and feeling supported. Student engagement is linked to student achievement and retention, as evidenced in many studies which are summarised by Trowler and Trowler (2010). The importance of student engagement is undeniable and responsibility to improve it relies not only upon the lecturer, but also upon the student, institution and government (Kahu, 2013).

It is important to emphasise that student engagement depends on class sizes and it is much more challenging to engage with large classes, compared to small classes (Exeter, et al., 2010). In particular, Ahlfeldt, Mehta, and Sellnow (2005) show that the smaller the class size is, the more students engage.

In this paper, student engagement will be associated with student attendance and active participation. This study focuses on student engagement in the 'standard' tutorial classes of a large second year undergraduate statistics module. (In the rest of the paper, tutorials will refer to 'standard' tutorials.)

2.2. Tutorials

This study focuses on student engagement during tutorial classes. A tutorial is normally a class in which a small group of students interact with a tutor. It is a learning opportunity in which students can exercise knowledge gained during lectures by asking questions, discussing problems with a tutor and/or peers, challenge other students' arguments or otherwise actively engage. Tutorials can be more interactive than lectures, and provide a personalised way of learning and involve a social aspect (Maharaj, 2012). There are many forms of tutorials, which may depend on discipline, modular or institutional requirements, or the tutor's experience. Tutorials are important and valuable for students' learning since they provide opportunities for students to discuss problems and ask questions in order to consolidate their knowledge and understanding and to deepen their understanding. To allow this, it is essential to promote active and collaborative learning methods in tutorials, which are well evidenced to improve student performance and retention (Beichner, et al., 2007; Freeman, et al., 2014). This is especially important in mathematics tutorials since students learn mathematics by actively solving problems, exploring mathematical concepts and ideas by themselves and/or with peers. Learning mathematics can be compared to learning to play a piano – as Mazur said about learning: "*Suppose you want to learn how to play a piano, you just don't go to a concert hall and listen to a famous pianist playing piano, you've got to play the piano*" (Scherpmedia, 2016). Smith (2008) also concluded that students consider tutorials promoting active learning as the most important part of their learning process.

In recent years, in many universities, the number of students accepted to courses has been growing, which has caused class sizes to become significantly larger, and this in turn has affected student engagement (Ahlfeldt, Mehta, and Sellnow, 2005). Due to a lack of resources in many modules in the

department, a tutorial is no longer a class with a small group of students and a tutor, but a large class (up to 200 students) with many different tutors in one room. Even in large groups, tutorials can still be effective and valuable to students' learning as discussed by Menard, et al. (2015). However, it becomes challenging to engage large groups of students during tutorials and many methods promoting active learning become impracticable.

There are several papers exploring different styles of mathematics tutorials promoting active learning and engagement, however, only a handful make suggestions which could be applied to large tutorial classes. Seaton, King, and Sandison (2014) discuss a very exciting style of mathematics tutorials – a so called board tutorial. A board tutorial takes place in a special room where boards line all walls of the room and all students in the class work through problems on their section of the board, in pairs or on their own. The tutor is a facilitator and guides students if needed. These tutorials have great benefits: they promote active and peer learning, increase confidence, and enhance communication skills and teamwork. There is no doubt that this type of tutorial greatly increases student engagement. However, due to the special requirements on rooms and high demand on numbers of tutors, it is not possible to run these tutorials for large classes of students when resources are limited.

Shearman, Rylands, and Coady (2012) describe an intervention aimed at mathematics tutorials that improved student engagement and performance. The intervention involved the following: tutorials during which material was presented by a tutor were replaced by so called workshop tutorials, in which the tutor was a facilitator, and assisted students while they were working on problems themselves. Another study by Sharma, Mendez, and O'Byrne (2005) showed that workshop tutorials are valuable for student learning. This study provides evidence that, on average, tutorial attendance improves student performance in examinations, and shows that especially less able students benefit from attending these tutorials. Although both studies provide evidence that tutorials with active learning elements improve student engagement and performance, the tutorial groups in both studies were rather small: in the first case, there were 30 students per tutorial group and in the second, 60 students per tutorial group. Based on my own and my colleagues' experience, when this approach is applied to larger tutorial groups, student engagement suffers significantly.

Other studies suggest to split large classes into smaller tutorial groups of 20-30 students and implement collaborative learning methods (Maharaj, 2012; Oates, et al., 2005). Menard, et al. (2015) discussed that collaborative learning methods may not be very effective in large tutorial classes (70 students). Perhaps collaborative learning methods were not as effective as expected due to the learning space. Brooks (2011) and Cotner, Loper, and Brooks (2013) discuss that a suitable learning space can promote benefits of active and collaborative learning and evidence suggests that an active learning classroom (e.g. a room with round tables) has a positive impact on student performance. It is worth pointing out that in the 2013 study, active and collaborative learning strategies were successfully employed in an active learning classroom with more than 100 students.

In conclusion, it seems that the most effective tutorials, from the point of view of student engagement and learning, are those tutorials which incorporate active and collaborative learning methods, and are small in size, ideally 20 to 30 students per group, or they take place in a room suitable for active and collaborative learning.

2.3. Student engagement in large classes

Studies focusing on promoting student engagement in large classes suggest implementing certain assessment strategies (Cole and Spence, 2012; Voelkel, 2013) and/or use technology, in particular, electronic polling systems (Goff, Terpenny, and Wildman, 2007; Kappers and Cutler, 2015; King and Robinson, 2009; Sawang, O'Connor, and Ali, 2017). It should be noted that these studies consider a large class to consist of 80 to 300 students. There are two studies that discuss student engagement in

classes with more than 500 students (Exeter, et al., 2010; Jarvis, et al., 2014). In particular, Jarvis, et al. discuss a concept and interesting strategy for a flipped-classroom approach. Although these studies focus on engagement in lectures, some approaches can be easily adopted to tutorial classes. However, many of the approaches would require a significant amount of resources, facilities and time investment; e.g. splitting my class into smaller groups would create a large demand on facilities and staff. Due to pressure on these essential resources, it is not possible to apply most approaches in our context.

The most frequently suggested approach to improve student engagement in large classes is using polling systems which enable students to respond to questions anonymously in class in real time, with immediate feedback. There are many studies evaluating different types of polling systems (clickers, online polling systems using mobile phones, etc.). A comprehensive summary and literature review of different systems is provided by Florenthal (2018) and Çakır (2020). It has been consistently evidenced that polling systems are very effective for improving student engagement, (e.g. Han, 2014; Sun, 2014). The following benefits of using polling systems were identified and taken from Cubric and Jefferies (2015):

1. classroom benefits: improvements in attendance, participation, and engagement;
2. learning benefits: the increased quantity and quality of class discussion, learning performance, quality of learning and contingent teaching;
3. assessment benefits: improved feedback, effective formative assessment, the ability to compare performance with others.

It has also been shown that students perceive polling systems positively with respect to learning and classroom experience (Cubric and Jefferies, 2015), and Kappers and Cutler (2015) and Noel, Stover, and McNutt (2015) show that students consider mobile-based polling an enjoyable experience. Tobin, Lozanovski, and Haeusler (2013) use a student response system successfully in a tutorial setting. Because of this overwhelming evidence and with many online polling systems available and easily accessible, it seemed to be very appropriate and was relatively straightforward to apply this approach in my tutorial classes.

3. The Intervention

In an attempt to motivate students in the class to attend and actively engage in the tutorial, a short quiz at the beginning of the session was introduced. This quiz was facilitated by Poll Everywhere (2023) and comprised of 4 short multiple choice questions, usually with four or more distractors. The questions were designed to help revise knowledge required to solve the problems on the tutorial sheets. For less able students, the quiz was intended to give students an idea what to consider in order to solve problems; for well-prepared and more able students, the quiz was an opportunity to consolidate knowledge. The quiz also served as a self-diagnostic exercise for all students.

After introducing each multiple choice question, students used their mobile phones or other devices with Internet connection to answer the question. A summary of student answers was released, and for each distractor feedback was provided, explaining the reasons why distractors could not be a correct answer.

After the quiz was completed (the quiz took usually 10-15 minutes), the usual form of tutorial resumed: students were expected to work on problems themselves or with peers and ask the member of staff or tutor when they encountered any problems.

Poll Everywhere was chosen as the most suitable polling system because it supports LaTeX which is the most effective typesetting software for mathematical symbols and expression, and also the

University owns a full Poll Everywhere subscription. Many challenges connected to hardware and software of polling systems which were indicated in the literature (Cubric and Jefferies, 2015; Rose, 2019) were overcome thanks to development of mobile polling systems for which students use their own devices. Another challenging issue is that polling takes up some of the delivery time and careful consideration should be given when allocating time for polling to ensure that the required course material is still fully covered. These timing concerns are not an issue in the tutorial setting, since a tutorial is time for students to revise, practice and consolidate their previously gained knowledge and so there is enough time to introduce learning tools requiring time investment. An initial challenge may be for presenters to get familiar with the polling software, however this software does not have a particularly steep learning curve. Another challenge that may arise is if a student does not own a device with Internet connection, although nowadays this is highly unlikely. However, such students could still take part in the quiz by writing their answers down and they were encouraged to do so. No software or connectivity problems were encountered when presenting the quiz using Poll Everywhere.

4. Methodology and Research Questions

The purpose of this study is to investigate whether the Poll Everywhere quiz introduced at the beginning of the tutorial classes improved student engagement, and to explore student perceptions of the quiz for their engagement and learning. Two aims are proposed which were based on results of studies by Kappers and Cutler (2015) and Noel, Stover, and McNutt (2015). The difference between these two and our own study is the setting in which mobile polling system is used; our study focuses on the tutorial setting. We will discuss whether the proposed aims were achieved.

Aim 1: The Poll Everywhere quiz improved student engagement with tutorial classes.

To see whether this aim was achieved, attendance in tutorials was taken by manually counting the number of students present in the class. No official attendance monitoring was in place, since this might have increased attendance numbers artificially creating a bias in our study; when attendance monitoring is in place, many students might attend for the sake of attendance records, however the quality of their engagement may be lacking. Moreover, this kind of extrinsic motivation is linked to surface approach to student learning as opposed to intrinsic motivation promoting deep learning (Biggs and Tang, 2011), which would hopefully be encouraged by making the tutorials as effective as possible for learning.

Since tutorial classes were not officially monitored, we could argue that students who attended these classes were intrinsically motivated to do so and participated actively in the classes either by taking part in the quiz and/or solving problems on tutorial sheets. In this study, attendance may therefore be considered as a valid measure of engagement since it actually accounts for active participation, that is good quality engagement.

As the Poll Everywhere quiz was included in three tutorial classes, attendance was taken for these three tutorials.

Data from Poll Everywhere also provided information about the exact numbers of students who participated in the quiz.

Aim 2: Students felt that the Poll Everywhere quiz made tutorial classes more engaging and helped their learning.

To see if the second aim was achieved, an anonymous online survey asking students about their experiences with the Poll Everywhere quiz was conducted. The online survey was conducted using an institutional account on the Jisc Online Surveys platform. All 541 students registered on the module

were invited to fill in the online survey via an announcement on VLE, explaining all details of the study. The survey was streamed into two sections according to whether students had attended at least one tutorial or they had not attended any. For those who had not attended any tutorials, there was just one open-response question asking about the reasons for non-attendance. The part of the survey for students who attended some tutorials consisted of a question about their tutorial attendance and four five-point Likert scale items, asking details about their tutorial learning experience. The survey also contained two qualitative open-response questions. The first open-response question gave participants the opportunity to elaborate their responses to the Likert scale items and the second one asked about further comments on the Poll Everywhere quiz and participants' perceptions of the overall structure of tutorials. Additional demographic information was collected to identify whether participants were home students, students from the Chinese university or other international students.

4.1. Data analysis

To analyse the collected data, descriptive statistics were used for tutorial attendance, participation in Poll Everywhere quiz and responses to the Likert scale items. For the two open-response questions, qualitative thematic analysis was used which is a common method for analysing open-response questions in surveys (Braun and Clarke, 2006). The responses were examined for themes, and relevant themes were then linked to corresponding aims. In particular, two main themes arose; one was "*student engagement*" which can be linked to both Aim 1 and Aim 2, and the other was "*student learning*" which is linked to Aim 2.

5. Results

The tutorial attendance numbers and rates are summarised in Figure 1 and Table 1. There were three tutorial classes in this module and the intervention was conducted in all three tutorials.

The average attendance for tutorials was 39.2%. Precise tutorial attendance rates from previous years are not available, however it is estimated that average proportion of students who attended equivalent three tutorials in past was approximately 25%. (This estimate is based on past experience of the lecturer and tutors.)

Interestingly, in every tutorial a small number of students left the class as soon as the Poll Everywhere quiz was completed.

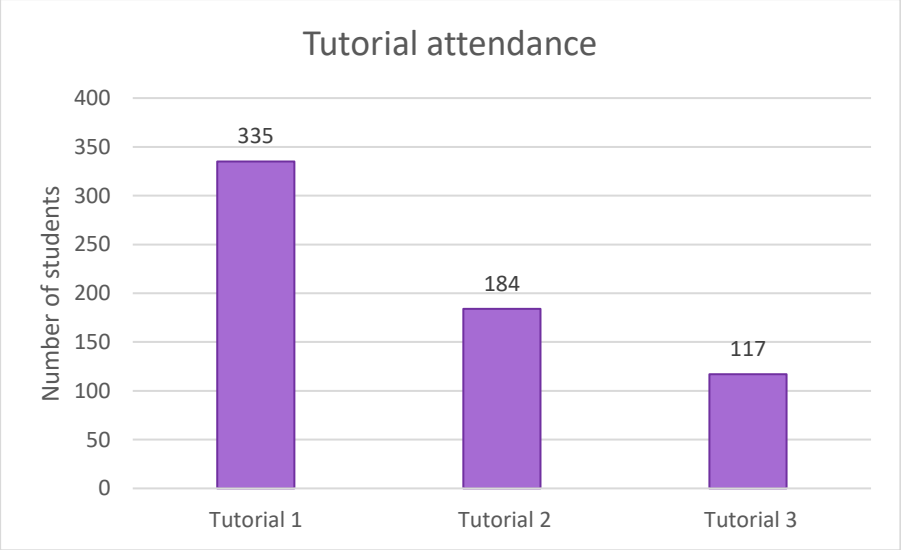

Figure 1**.** Tutorial attendance: number of students in each tutorial, out of total 541.

Table 1. Tutorial attendance rates: proportion out of 541 students who attended each tutorial

Tutorial 1	Tutorial 2	Tutorial 3	Average attendance
61.9%	34.0%	21.6%	39.2%

Table 2 summaries the proportions of students present in the class who participated in the Poll Everywhere quiz at the beginning of the tutorial.

Table 2. Engagement rates with the Poll Everywhere quiz: proportion of present students who participated in the Poll Everywhere quiz

Tutorial 1	Tutorial 2	Tutorial 3	Average engagement
97.0%	73.4%	82.9%	84.4%

Data suggest that a high percentage of students who attended tutorials took part in the quiz; average engagement with the quiz was 84.4%.

The online survey received n=21 responses. The survey was completed by 11 home students and 10 students from the Chinese university. Out of all respondents, 15 attended all three tutorials, 5 attended first two tutorials and one respondent attended the first tutorial only. No survey responses were received from students who did not attend any tutorials, and so reasons for non-attendance could not be identified in this case.

The results of Likert scale items are summarised in Table 3 with scale 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree.

Table 3. Summary of the results of questionnaire Likert scale items

	1	2	3	4	5	mean	st.dev.
(1) The quiz at the beginning of the tutorial helped me to revise my knowledge of the material.	0	0	3	7	11	4.38	0.74
(2) The quiz at the beginning of the tutorial encouraged me to participate in the tutorial.	0	0	4	8	9	4.24	0.77
(3) The quiz at the beginning of the tutorial helped me to engage successfully with the tutorial sheet.	0	4	4	12	1	3.48	0.87
(4) Overall, I found that the quiz at the beginning of the tutorial was useful for my learning.	0	0	3	10	8	4.24	0.70

All Likert scale items received, on average, positive responses of agree or strongly agree. Students believed that the Poll Everywhere quiz helped them to revise their knowledge (mean=4.38,

st.dev.=0.74), and encouraged their tutorial participation (mean=4.24, st.dev.=0.77). The lowest rating was received for the item asking whether the quiz helped students to engage successfully with the tutorial sheet (mean=3.48, st.dev.=0.87). Overall, students felt that the quiz was useful for their learning (mean=4.24, st.dev.=0.70).

A few open responses were received. Some open responses were relevant to both aims, and these formed the theme "*student engagement*". For example, those were responses stating that students "*felt engaged during tutorials*". Generally, responses stated that the quiz was "*very useful*" and "*meaningful*" and these were linked to the theme "*student learning*". Students appreciated that the quiz was anonymous and that feedback was explained in detail. It was suggested that the quiz could have contained more questions and more challenging questions.

6. Discussion

6.1. Aim 1: The Poll Everywhere quiz improved student engagement with tutorial classes

It seems that the Poll Everywhere quiz had a positive impact on student engagement with tutorial classes; the average attendance rate was 39.2%, which was observed to be greater than in the past when the average attendance rate was around 25%. Even though the 39.2% attendance rate does not seem very high in general, it is a good result in the current setting, since the tutorial classes are optional and are not directly associated with continuous assessment, suggesting that students seemed to be intrinsically motivated to attend. Other modules in the department which adopt a similar tutorial style (but without using Poll Everywhere), and which have large numbers of students, typically report very low attendance. No attendance data is formally recorded for these modules, but in this context the average attendance rate of 39.2% is notable. One can notice that attendance rates decreased as the semester progressed. This is quite a common phenomenon which was also observed e.g. by Kassarnig, et al. (2017), however this paper does not explore the underlying reasons. In my class, the first tutorial always has the highest attendance, possibly because students want to identify whether the class is "*valuable*" to them; as discussed by Massingham & Herrington (2006), most students attend classes if they perceive them as "*valuable*". Even though exact data are not available, it was observed that this year's second tutorial seemed much better attended compared to previous years, suggesting that the quiz attracted more students to attend and actively engage. The reasons for the significant decrease between the first and second tutorial are unclear and deserve further investigation. This drop in attendance may be attributed to one of the reasons discussed in the introduction and it may suggest that the quiz was not a sufficient motivation for some students to attend the tutorials.

Data show that not all students who attended tutorials engaged with the quiz using a device. However, these students might have still engaged by writing their answers down. Some students did not participate in the quiz because of their late arrival. Bennett and Voelkel (2014) observed that not all students present in a class participated in polls. According to students' views, it was because sometimes they just did not have a mobile phone with them or they just preferred to think about the question quietly without answering actively. The authors also concluded that a typical poll's response rate dropped when questions became more complex or difficult since, for example, students required more time to answer. Although in our case the quiz questions were not complex or difficult, some students could perceive them as such, and perhaps needed more time to answer. Even if the students did not complete the quiz actively, they could still take part passively and learn from feedback provided after each quiz question. Even if some students did not participate in the quiz, they still attended the tutorial in order to engage in a different way: they attempted to solve the problems on the tutorial sheet and/or engaged in discussions with their peers, tutors or a member of staff.

Another indication that the quiz encouraged student attendance is the fact that some students left the tutorial as soon as the quiz ended. One open response in the survey also stated that students "attended

specifically for the quiz." Although this may not be an intended result, it was observed only in a small number of cases and the quiz alone had some educational value for student learning. On the other hand, many of those students who attended only for the quiz possibly stayed after the quiz ended and worked on the tutorial problems, which is a very desirable result. However, this is an interesting phenomenon which may indicate that some students believe that they would miss out on a learning opportunity if they did not participate in the quiz, but they would not miss out on any valuable learning opportunity by avoiding the rest of the tutorial. This suggests that some students place higher value on teacher-directed activities rather than student-directed/independent learning activities. Another reason for students to leave the tutorial earlier could be that they answered all quiz questions correctly and perhaps felt that they achieved sufficient knowledge of material. Although the quiz was advertised as a learning opportunity to help students to revise some necessary knowledge for the tutorial sheet, perhaps in future it should be stressed that students should engage with the problems on the tutorial sheet as well since it provides another important and valuable opportunity to help their learning and understanding.

Some open responses in the survey also supported Aim 1; respondents stated that students "*felt engaged during tutorials*" and that "*the quiz made the tutorial for this module the most useful this year as it engaged us more than any other set of tutorials*". This suggests that the quiz gauged some students' interest, motivated them to attend tutorials and to engage actively.

6.2. Aim 2: Students felt that the Poll Everywhere quiz made tutorial classes more engaging and helped their learning

Likert scale survey items (2) and (3) were related to students' perceptions of engagement. There were very favourable responses for item (2), suggesting that students felt strongly that the quiz promoted their participation in the tutorial. However, for item (3) the lowest ratings were received. There were four respondents who disagreed that the quiz helped with engagement with problems on the tutorial sheet. Even though the quiz questions were related to the problems on tutorial sheets, this indicates that they did not help some students to tackle the problems and some students could not find connections between the quiz questions and tutorial problems. Clearer communication of connections between the quiz questions and tutorial problems could be made in future, to help students engage with tutorial problems. In particular, this would be of benefit to less able students. Clearly communicated learning outcomes and constructive alignment with learning outcomes are related to increased student motivation which contributes to better student engagement (Stamov, et al., 2021).

Some open responses can be also directly linked to support Aim 2. As discussed before, respondents stated that they felt engaged and that the quiz made students engage more compared to other tutorials. Increased student engagement in classes using Poll Everywhere was also confirmed in other studies (e.g. Bennett and Voelkel, 2014).

Likert scale survey items (1) and (4) explored the effect of the quiz on students' learning. Both items received very positive responses, indicating that students believed that the quiz helped their learning. This is also supported by open responses, stating that the quiz was a very useful and meaningful activity. Benefits of polling systems on students' learning of mathematics were also confirmed in other studies (e.g. King and Robinson, 2009). Some respondents even suggested that the quiz questions could be more challenging. Adding more challenging questions could however demotivate less able students and the quiz could lose its intended purpose, that is to be inclusive and inviting for students of all abilities. Moreover, differentiation of abilities is achieved through problems on tutorial sheets and discussions with peers and/or tutors and therefore there is no need to make the quiz questions more challenging. There might be scope to include a few more quiz questions as suggested in some responses, however time limitations should be considered when including more questions; in my opinion, a longer quiz could introduce a risk of 'quiz fatigue' (cf. survey fatigue; Porter, Whitcomb and

Weitzer, 2004) and also interfere with the other important part of tutorial where students attempt to engage with tutorial problems. A careful balance between the two parts of the tutorial would have to be considered.

7. Conclusion

It seems that both aims were achieved, suggesting that the Poll Everywhere quiz increased student engagement with tutorials and that students felt that the quiz had a positive impact on their engagement and learning. This is in agreement with results of similar studies, (e.g. King and Robinson, 2009; Kappers and Cutler, 2015; Rose, 2019). However, there are some limitations to this study. There are no exact attendance data available from previous years, and respondent bias may be present; students who enjoyed the quiz may be more inclined to respond to the survey. Despite this, the study indicated that introducing the Poll Everywhere quiz was successful and a step in right direction to improve student engagement in tutorials and students seemed to enjoy it.

Although possible reasons for disengagement in tutorials were outlined earlier, it would be desirable to formally explore the reasons in the setting of tutorials. This knowledge may help to further enhance the current tutorial structure or design a new structure which could help to increase student engagement even more. However, the intervention presented in this paper seems to be an effective, innovative and easily applicable way to make tutorials more engaging and beneficial to students' learning. This approach may benefit tutorials of other large, and also small modules and is not restricted to mathematics subjects, but can be easily applied to other disciplines.

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