Classroom Response Systems: Inclusion, Attainment and Active Learning

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Abstract

The 'clickers project' is a University-wide project, designed to provide an inclusive facility for technology-enhanced learning to staff and students.

Every level 4 student received a free clicker device. Students were asked to register their clicker using the University's virtual learning environment (VLE) in order to investigate student engagement with in-class quizzes using clickers. Participation in the clicker registration process was recorded and evaluated as an indication of engagement with classroom technologies.

Overall, significant differences in progression and participation in the registration process were observed with respect to ethnicity, gender and non-continuation rates for full-time, first degree entrants. In an accompanying survey, students who were less confident in their in-class responses were more likely to resist working with peers or to give-up more quickly when tackling difficult questions.

This paper presents three key elements of the project: First, Kingston University's inclusive approach in promoting classroom technology, second, analysis of engagement with the clicker registration process, and finally student perceptions of the use of classroom technologies. The objective is to show how classroom technologies can be seen as inclusive tools for feedback, capable of providing early signs of gaps in attainment among learners.

Introduction

The "clickers project" at Kingston University adopted a roll-out strategy similar to projects discussed by Jefferies (2011) and Cubric & Jefferies (2015). This included technical support, training and information for staff and students from the beginning. The university-wide roll-out was a result of a successful internal pilot which ran in 2015 with 500 Mathematics and Life Science students. The pilot data evaluation from focus group interviews with staff and students accompanied by a survey revealed that clickers were considered by staff and students as an accessible way to stimulate engagement. These outcomes are consistent with what reports elsewhere in the literature (*e.g.* Caldwell, 2007; Trees & Jackson, 2007). The students in the pilot study reported that the use of clickers helped to improve engagement, feedback, interaction, peer discussion and the clarity of content. Clickers were seen as a useful tool to foster participation and counter a lack of confidence, to receive immediate feedback and to

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increase interaction in unresponsive large classes and groups. These findings are mirrored in previous studies and literature reviews on classroom technologies (Caldwell, 2007; Liu *et al*., 2009; Mayer *et al*., 2009; Kay & LeSage, 2009; Surgenor, 2010).

The clickers project is based on an inclusive strategy, to give every level 4 student a physical 'clicker' without any cost to the students. The strategy is designed to counter concerns about disenfranchising students from lower socioeconomic backgrounds. Staff views from focus group interviews supported this inclusive approach which is aligned with the University's Inclusive Curriculum Framework, which was created to improve retention, progression and to reduce the attainment gap between black and minority ethnic (BME) and white students (McDuff & Hughes, 2017). The data from Kingston University suggests that there is a difference in the degree outcome between BME[1] students and white students even when the students have identical entry qualifications and have studied the same subjects. The attainment gap is calculated using a value added score, which takes into account degree outcomes for all graduates across the UK, broken down by entry qualifications and subjects studied to create a probability of achieving a first or a 2.1 degree for a full time first degree cohort. If the cohort performs as expected, the value added score is 1.0. A value added score greater than 1.0 indicates that a cohort performed above the expected degree outcome whereas a value added score below 1.0 indicates that a cohort performed below the expected degree outcome.

The reviewed literature on classroom technologies (Caldwell, 2007; Mayer *et al*., 2009; Surgenor, 2010) often describes the benefits and challenges of using classroom technologies in learning and teaching. It is clear that there is currently a lack of evidence around the manner in which classroom technologies can be used to identify gaps in engagement among students in earlier stages of their learning and before their final degree outcome. This type of learning analytics is relevant to universities which intend to invest in classroom technologies and tackle attainment at the same time.

One aim of this paper is to present how the promotion of inclusive active classrooms with clickers, and the use of clickers in teaching, reveals significant differences between students in their engagement with the clicker registration process and its association with continuation. Alongside this, the paper presents students' own perceptions on the value and usefulness of clickers in learning and teaching.

Method and Results

In this section, two sets of data are presented. First, clicker registration and progression data are used to investigate differences between groups of students based on their socio-economic, age, gender and ethnicity. The second section presents data from a survey of the students perceptions of clickers.

Student engagement and progression

In 2015/6 all Level 4 students in the Faculty of Science, Engineering and Computing (SEC) and Faculty of Business and Law (B&L) received a clicker, accompanied by a consent form that outlined data collection and use. The students were encouraged to register the unique ID of the clicker on the VLE and this data was then combined with their results. This set of data provided an opportunity to investigate whether engagement with clickers was correlated in any way with student progression data. The clicker registration process was voluntary and mediated via the VLE, the act of registration is related to engagement (which in itself is a multi-faceted student trait): even though "engagement with the registration process" is not the same as "engagement with studies", analysis of registration *per se* provides insight into an aspect of student behaviour.

The dataset comprises records, including self-reported ethnicity, clicker registration and module results, from 1,926 level 4 students from the Science Faculty (B&L students were not included due to the availability of data). A fraction of 61.8% of students registered their clickers. Registration rates were similar

[1] Using the HESA definition of "BME".

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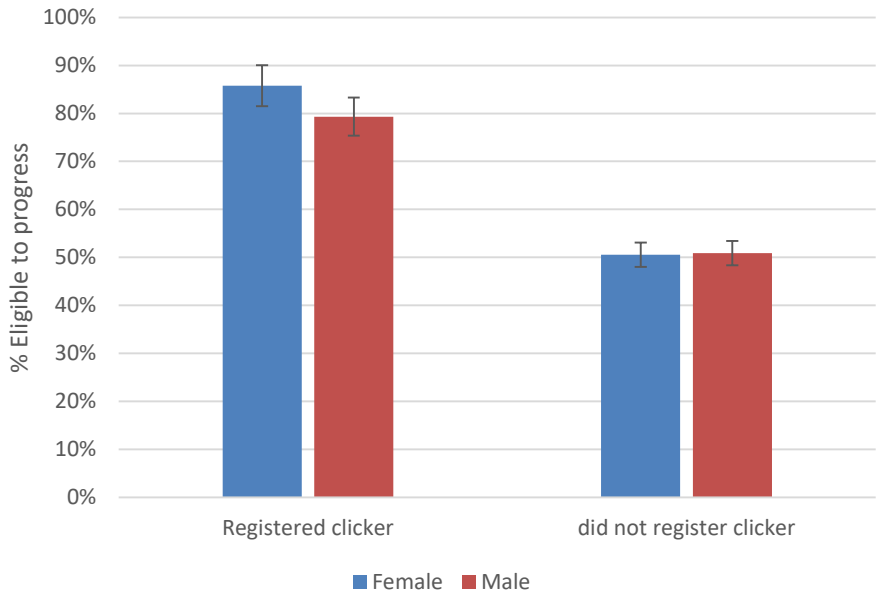

Figure 1: Proportion of female and male students with and without clickers who were eligible to progress at the end of 2015/16 academic year

across all student demographic groups with the exception of gender. Female students (73.1%) were much more likely to register their clickers than male students (55.5%). Analysis of student outcomes showed no significant differences in progression rates between socio-economic groups and age when stratified by clicker registration. That is, whilst there were differences in progression between young and mature students, for example, the differences were the same, statistically-speaking, whether or not they registered their clicker. However, significant gender and ethnicity differences in progression rates were observed depending on whether or not the students engaged with the clicker registration process.

First (Figure 1), females who registered their clickers were associated with higher progression rates than males ($\chi^2(1, N = 1935) = 7.53, p = .006, \phi_C = .08$), reflecting their higher engagement with the clicker registration process. Whilst progression rates were generally much lower for students who did not register their clicker, no significant gender differences were observed.

Secondly, as shown in Figure 2, a significant association was observed between progression outcomes and ethnicity for students who did not register their clickers ($\chi^2(1, N = 1726) = 5.73, p = .017, \phi_C = 0.093$). That is, considering the students who disengaged with the clicker registration process, BME students were less likely to progress than their non-BME peers, whereas the progression "gap" between BME and white students who engaged with the registration process was smaller and not statistically significant ($\chi^2(1, N = 1726) = 0.36, p = .550$). This suggests that there are groups within the BME cohort with different likelihoods of progression and that the mechanism of registration may be a useful "engagement proxy" that could be used in a learning analytics system to identify this group and direct support approaches appropriately (Mountford-Zimdars *et al*., 2017; Gordon, 2016).

Overall, the analysis showed that 90.3% of full time, first degree students in the Faculty of Science who registered their clickers in 2015/16 continued with studies in 2016/17 compared to 72.6% of students who did not register their clickers. Student engagement with the clicker registration process was significantly associated with lower non-continuation rates for full time, first degree entrants ($\chi^2(1, N = 1098) = 53.17, p < .001, \phi_C = 0.220$), suggesting that students who did not engage were 2.8 times more likely to discontinue their studies in the first year of entry.

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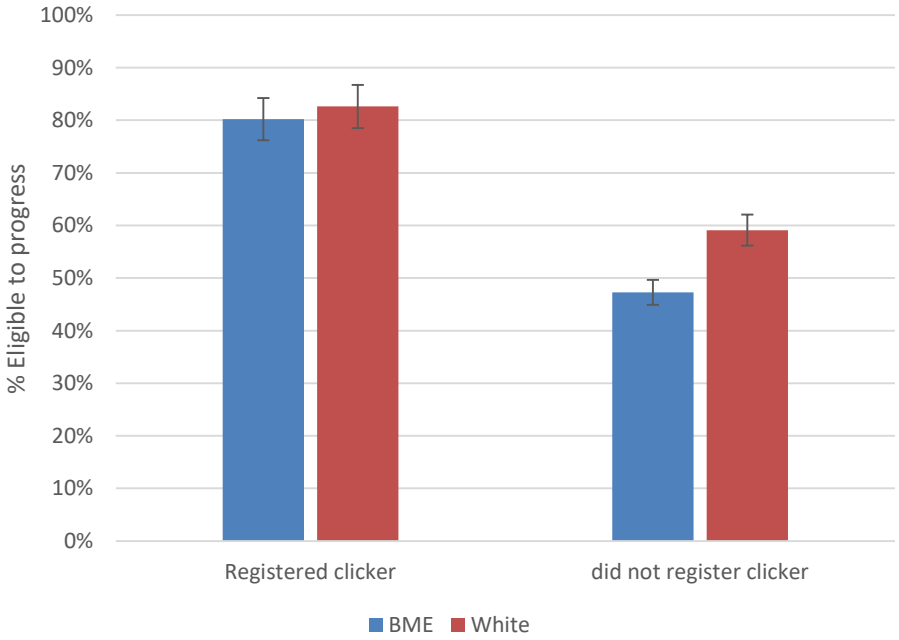

Figure 1: Proportion of students from different ethnic groups with and without clickers who were eligible to progress at the end of 2015/16 academic year

Student perceptions survey

In the second year of the project (2016/2017) all Level 4 students in SEC and B&L again received a clicker, as well as any Level 5 students without one (such as direct entrants or repeating students). The differences in engagement with the registration process that had been identified in the previous year of the project prompted the desire to investigate students' attitudes to clicker usage, similarly to Prather & Brissenden (2009). A survey was developed in collaboration with students as part of a "SADRAS" project (Williams *et al*., 2016) and deployed to a sample of modules in SEC and B&L, which aimed to identify differences in students' opinions about clicker usage between BME and white student groups. (The survey questions are in Appendix 1.) The sample comprised modules where academics responded to an email requesting time in a class to run the clicker-based survey, thus targeting groups actively using clickers. Overall 472 students participated in 12 different classes in the SEC and B&L from 1st to 3rd year undergraduates.

Respondents' demographics were remarkably balanced between the two faculties, as shown in Figure 2, with almost identical proportions of students in B&L and SEC who were BME/White (68%/23% in B&L and 68%/22% in SEC, with the remainder declining to respond) and male/female (49%/36% in B&L and 50%/39% in SEC).

Even though the proportions of various student groups does vary within the various SEC subject areas, a standard *t*-test using SPSS suggests the differences are not significant given the sample sizes (mathematics $n = 58$, computing $n = 134$, engineering $n = 40$, life sciences, pharmacy & chemistry $n = 86$).

Furthermore, analysis of variance using SPSS (following de Winter & Dodou, 2010) show no statistically significant differences, at the 95% level, in the responses to survey questions between subject groups, gender or ethnicity. As a consequence the following figures contain just a summary of the questions and responses from all groups combined.

Responses from a variety of questions about the perceived benefits of clickers are shown in Figure 3. The majority of responses are positive (strongly/agreeing with a positive statement) with very few disagree responses, showing the predominantly positive perception

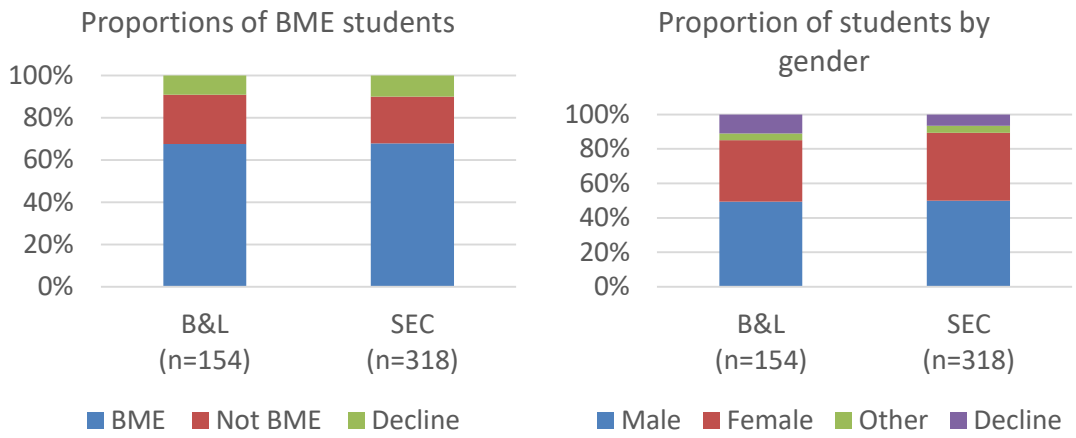

Figure 2: Demographics of survey respondents from Business (B&L) and Science (SEC).

of the clickers project. The weakest response mirrors the pilot survey from 2014/5 (Denholm-Price *et al.* 2015): students are somewhat equivocal about the utility of redoing (revising) in-class questions in their own time.

The students were asked how confident they felt when responding to a clicker question. Confidence in Figure 4 unsurprisingly centres around "70% confident". The confidence categories are relatively coarse and somewhat arbitrary, but there is a correlation between positive responses to clicker survey questions and higher confidence, with students who responded in the upper two confidence categories (99% and 90% confident; $n = 141$) giving, on average, 8% more "agree" responses to the Likert questions in Figure 3 than the less confident students ($n = 299$), although the pattern of responses is broadly unchanged (not shown) and not statistically significant.

Students' experience of "clicker fatigue" and the perceived purpose of the clickers project are examined in Questions 9 (Figure 5) and 10 (Figure 6). These were both "multiple answer" questions where the closed set of response options was based on students' verbal responses to similar question in the pilot study focus groups (Denholm-Price *et al.*, 2015) and can be found in Appendix 1.

Figure 5 shows that students are least likely to respond to a clicker question when tackling questions they perceive to be more difficult or questions that require working-out, as opposed to simply suffering from the clicker equivalent of "survey fatigue" (*i.e.* "more than 5 questions"). Less confident students were much more likely than their confident peers to not answer questions where peer-interaction was expected. The first two options in Figure 5 suggest that subjects like mathematics, where calculations are expected, should ensure that working-out is encouraged and rewarded, and the differences by confidence level suggest strategies like *peer instruction* need to be handled carefully if less confident students are to get the most from a session. Finally, question 10 (figure 6) suggests that the primary purpose of the clickers project (to promote active learning in the classroom) was quite well understood, with a slightly smaller number believing it was mostly about attendance monitoring, although there is still work to do in showing students the benefits of self-testing in the classroom. The difference in responses to Q10 in Figure 6 between students based on their self-reports of confidence in their answers to clicker questions is perhaps revealing: Less-confident students felt clicker questions were more about feedback and testing (for themselves as well as the lecturer) whilst for more confident students it was slightly more about peer discussion (mirroring the responses to Q9 in Figure 5).

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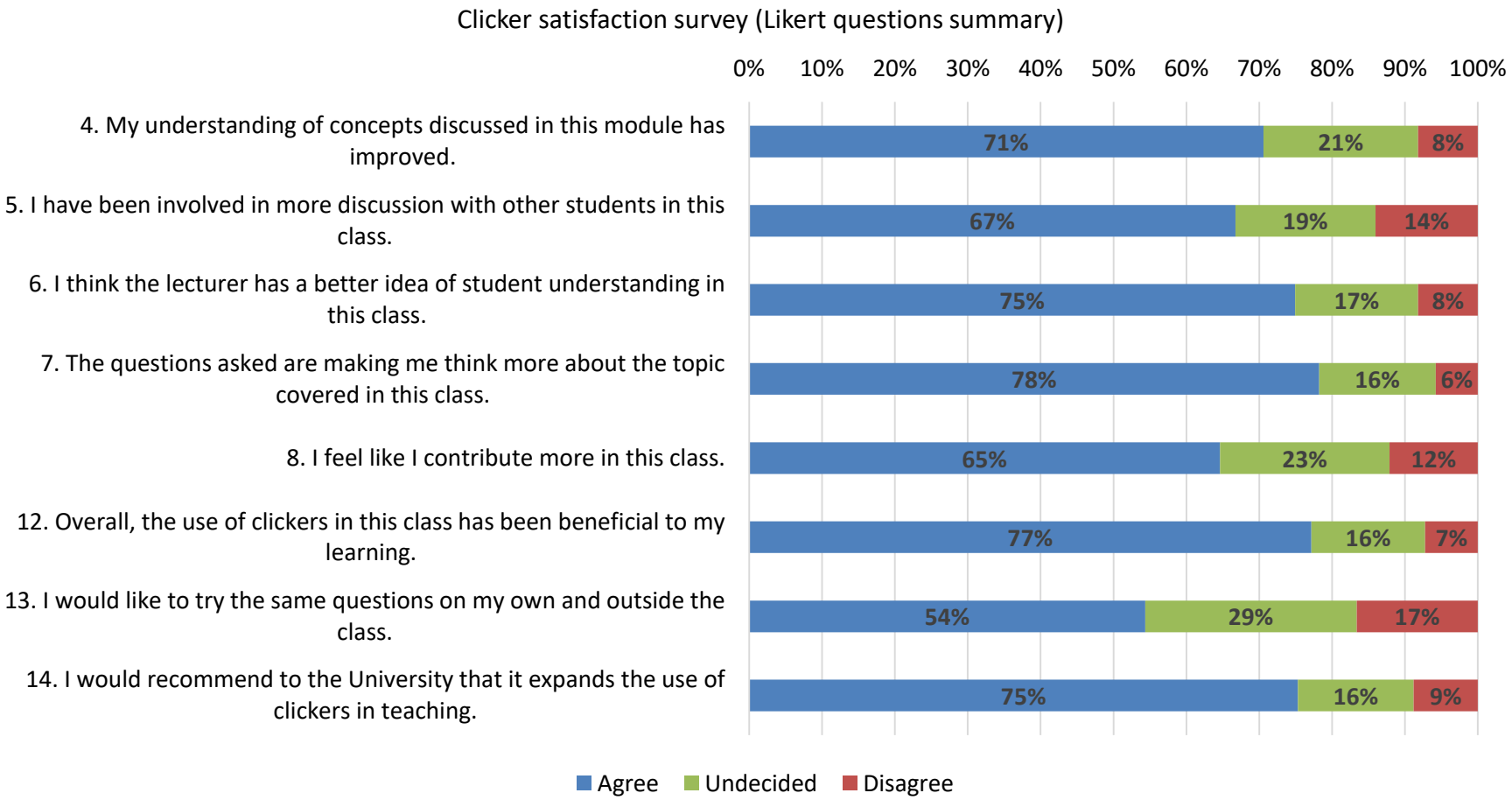

Figure 3: Summary of responses to the clicker satisfaction survey for questions 4-8, 12, 13, 14 (Likert scale questions).

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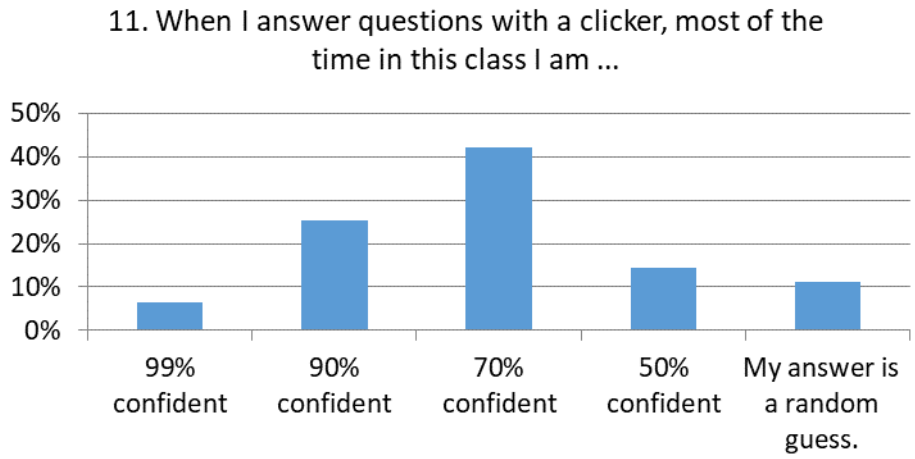

Figure 4: Student confidence levels when responding to in-class clicker questions.

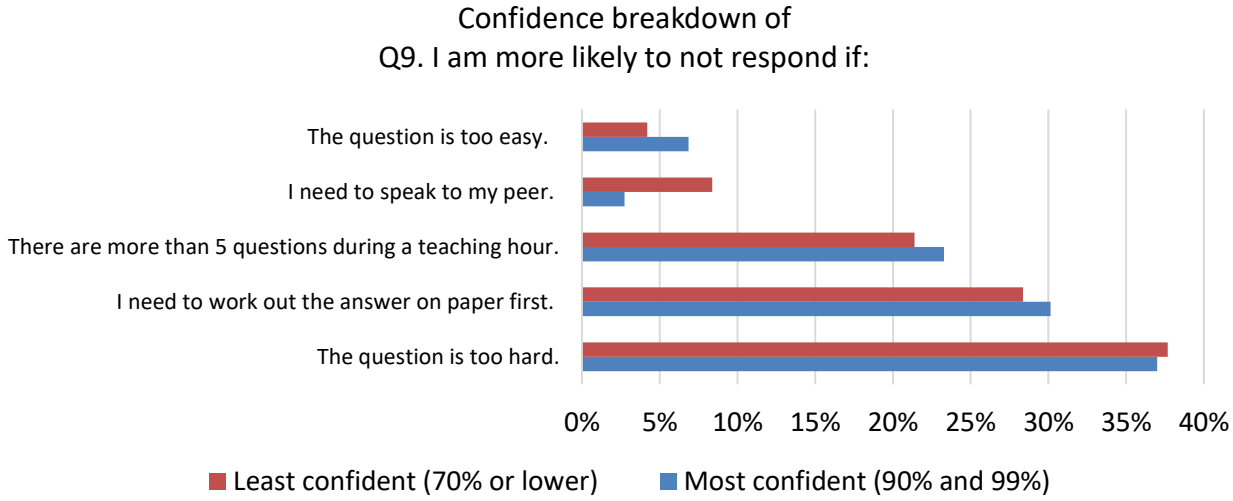

Figure 5: Exploring students' reasons for not responding to in-class questions (multiple answer question 9), partitioned by relative confidence level.

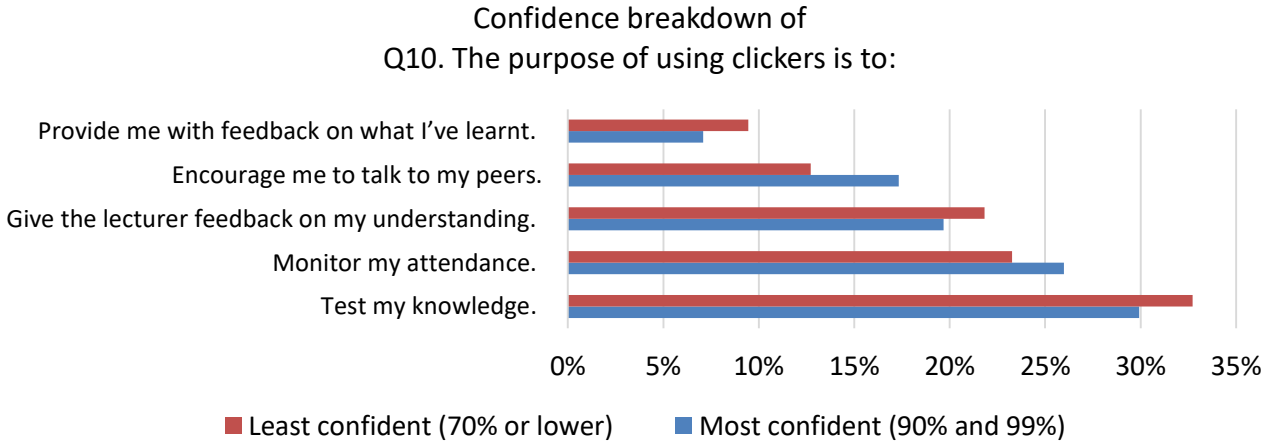

Figure 6: Student perceptions of the primary purpose of the clickers project (multiple answer question 10), partitioned by relative confidence level.

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Discussion and Conclusions/Recommendations

Attainment, progression and retention gaps are important metrics for the higher education sector. Narrowing gaps positively affects students' experiences, employment prospects, institutions' recruitment prospects, as well as being a reflection of changing societal mores. Kingston University has invested resources to confirm the existence of the BME attainment gap, the causes of the gap and consequently placed a number of interventions to minimise the gap in the degree outcomes among their students.

The analysis of clicker registration and progression data indicates two clear potential gaps: a gender progression gap and a BME progression gap. The gap was not statistically significant for these same groups, when considering only students who registered their clickers.

Arguably, engagement with the clicker registration process is not one of the common learning analytics techniques usually used to identify students 'At Risk' of not achieving their predicated outcomes. The research on learning analytics seems to focus on access to data about learners in early stages of their course because it is considered to be critical (Slavin & Madden, 1989). Typical indicators reported from learning analytics research are: grades, performance, self-evaluation, financial data and students' confidence in their subjects (Potgieter *et al*., 2010; Arnold & Pistilli, 2012; Agnihotri *et al*., 2014).

The clicker registration is merely related to engagement and was not strongly encouraged or enforced by a "policy" or module credit. The results do not necessarily portray a causative link but they are encouraging because the inclusive clicker policy means there are no socio-economic barriers to clicker registration. This means this type of inclusive TEL intervention can support an increase in access and participation without barriers to entry that might be caused by mobile phone ownership or data usage. This was evident from the registration rates which were well-balanced across groups.

The results presented in this paper are worth further investigation, especially, since very little has been reported on learning analytics from classroom technologies and its potential for narrowing the attainment gap. These types of interventions are appropriate and relevant, especially when universities are investing significant funds in purchasing and supporting classroom technologies as well as trying to narrow attainment and progression gaps. Learning analytics from classroom technologies has the potential to enhance the quality of teaching, to improve retention and to enable students to take control of their own learning (Sclater, Peasgood & Mullan, 2016; Graham *et al.*, 2007). It might be feasible to view engagement with TEL processes, like the registration of a clicker with the VLE, as an indicator for engagement and a significant potential for narrowing attainment, progression and retentions gaps. Moreover, there was no statistically significant difference in the perception of the utility of clickers between BME and non-BME students (or by gender). By giving a clicker to every student no barriers to inclusion were introduced, which has been a small concern in previous studies with mobile phone based response systems (e.g. Anthis, 2011) and should be borne in mind for future TEL intervention.

Some differences in student perception correlate with a measure for development of "confidence" which, whilst not the focus of this paper is a current topic in education and relevant to student achievement, progression, attainment and experience. Other survey findings are worth investigating further, for example, the fact that students are less likely to respond when attempting difficult questions and less confident students were more likely to not answer questions where peer-interaction was expected. This type of data is useful when students are asked to work with peers.

Overall, the results from three years of university-wide use have shown that good classroom technological practice is appreciated by staff and students. Therefore it is recommended to continue to provide universal access to classroom technology and to continue supporting staff with training and good examples of the use of technology in teaching. More can also be made of students'

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in-class response data by analysing the detail of responses and the question-to-question variation. For example, students who consistently answer questions incorrectly, or switch from correct to incorrect responses after peer discussion, could be identified from the device responses as a means to target further, perhaps one-to-one, support. Altogether, this would help cement the use of classroom technologies as a meaningful tool for learning and also as a tool for improving student support. It is hoped that these interventions will help to move from a focus on students' outcomes to a wider conceptual lens on active learning, feedback and equality within the University.

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Appendix 1:

Student perception survey questions

Q1 MA What would you consider to be your ethnic group?
Options:

- Arab,
- Asian (Chinese),
- Asian or Asian British (including Bangladeshi, Indian, Pakistani),
- Black or Black British (African),
- Black or Black British (Caribbean) White,
- Would prefer not to answer,
- Other not represented above

Q2 MCQ What gender do you identify as?
Options:

- Female,
- Male,
- Other,
- Prefer not to say

Q3 MCQ Clickers are used in my classes
Options:

- Three times a week or more,
- Twice a week,
- Once a week,
- Less than once a week,
- Never

Having used clickers in class: (5 point Likert scale questions)

Q4 Likert my understanding of issues/ideas/concepts discussed in this module has improved.

Q5 Likert I have been involved in more discussion with other students in this class.

Q6 Likert I think the lecturer has a better idea of student understanding in this class.

Q7 Likert the questions asked are making me think more about the topic covered in this class.

Q8 Likert I feel like I contribute more in this class.

Q9 MA I am more likely to give up answering questions if: …
Options:

- There are more than 5 questions during a teaching hour,
- The question is too hard,
- The question is too easy,
- I need to work out the answer on paper first,
- I need to speak to my peer,
- None of the above.

Q10 MA The purpose of using clickers is to …
Options:

- Encourage me to talk to my peers,

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- Monitor my attendance,
- Test my knowledge,
- Provide me with feedback on what I've learnt,
- Give the lecturer feedback on my understanding.

Q11 MCQ When I answer questions with a clicker, most of the time in this class:
Options:

- I'm 99% confident about my answer,
- 90%,
- 70%,
- 50%,
- My answer is a random guess.

Q12 Likert Overall, the use of clickers in this class has been beneficial to my learning.

Q13 Likert I would like to try the same questions on my own and outside the class.

Q14 Likert I would recommend to the University that it expands the use of clickers in teaching.

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