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Investigating the effects of a backchannel on university classroom interactions: A mixed-method case study

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ABSTRACT

Exploratory studies have started to demonstrate the potential value of digital backchannels for enhancing interaction in university lectures. The present study was conducted in a third year engineering course and involved the use of specialised backchannel software with the following features: students could anonymously post questions, vote on questions, give the lecturer feedback regarding the pace of the lecture or simply alert the lecturer that they were 'lost'. The study used a mixed-method data analysis design that, in addition to data automatically logged through the backchannel, included the use of observations, surveys, lecturer interviews and student focus groups. It was found that students used all features of the backchannel, with especial use of the 'like' feature, not currently available in most commercial backchannel packages. The backchannel increased the number of questions asked in class, and also resulted in a broader range of students participating in such interactions. There was limited evidence of the backchannel proving a distraction; on the contrary some students said that it helped them to focus more in class. From the lecturers' perspective the backchannel did require some modification of their lecturing style but they felt that the additional feedback that they achieved was valuable.

1. Introduction

Lectures are a common teaching tool in higher education. A typical characteristic of lectures is large class sizes, in which a well-recognized issue is passivity amongst students. Recently, digital backchannels have been implemented in lectures for their potential to disrupt this passivity and to promote active engagement. A backchannel, in the context of this study, is software that allows a secondary, digital conversation to take place during a university lecture; 'a non-primary communication channel between the speaker and the listeners, in which feedback is given to the speaker in [unobtrusive] ways' (Du, Rosson, & Carroll, 2012, p.127). In other words, the listeners are able to actively contribute questions but they do not interrupt the speaker at the point they are delivered. The software allows audience members to interact with the speaker using digital

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devices rather than verbally. This study draws together and aims to extend the emerging literature that is investigating the value of implementing a backchannel in a university lecture setting.

Lectures have a long history in university teaching, deriving from ancient scholarly traditions that pre-date the university. In recent times the lecture has received a wide range of criticism, mostly for a perception that as a pedagogical format it is antithetical to active student engagement. Indeed, the primary way in which students can participate in a lecture is by asking questions and this can be particularly intimidating in the large class sizes that are typical in many university courses these days. For some students, asking questions is viewed as a challenge to authority or simply impolite, while for others, the idea of embarrassment in front of peers is enough to prevent these students from asking a question. Furthermore, they may feel that they may annoy their peers by slowing down the lecture. These challenges are exacerbated in contemporary times where there can be a wide variety of academic backgrounds in the class – some students might need more input than others. Indeed, teaching for a broad range of academically able students is a common challenge in teaching, regardless of the teaching method used. However, it would appear to be most problematic in the lecture. Furthermore, as student bodies become more diverse, so do their home languages and this compounds the challenges students can experience with the typically fast-paced verbal delivery in the lecture. These issues are particularly pertinent in the South African university environment which provided the context for the present study.

2. Research on the use of digital backchannels in higher education

Digital backchannels have been around for just over a decade, with the majority of use during professional conferences, mostly Information Technology (IT) and Computer Science themed (Du et al., 2012). In these contexts Twitter – a popular micro-blogging platform – has been the software of choice. Based on how these backchannels ostensibly do not disrupt a presenter, and their success in conferences, the idea has now started to be adopted in some higher education lectures and there is an emerging literature that assesses this application. The introduction of this software to universities seems only to have occurred in trial runs or select courses – it is not yet considered a mainstream educational tool. Initially these backchannels in the lecture context were operationalised using the social media tools Facebook and Twitter but more recently, specialized software has been designed and used. Given the quite different affordances of the social media or the specialized platforms, we review these literatures in turn.

A limited number of studies have investigated the use of Twitter as an in-class backchannel (Bussières, Métras, & Leclerc, 2012; Camiel, Goldman-Levine, Kostka-Rokosz, & McCloskey, 2014; Fox & Varadarajan, 2011). Although each of these studies documents some take-up of this opportunity by students, they raise a range of concerns. The first is relatively limited take-up which has been noted in the studies by Bussières et al. (2012) and Welch and Bonnan-White (2012). This issue is countered by course designs which require students to tweet for course credits and predictably it has been shown that students conform with this requirement (Fox & Varadarajan, 2011). However, in this context it was found that a majority of students also indicated they found using Twitter distracting, a similar issue to that noted by Camiel et al. (2014) in their study. Overall it seems that the predominant social use of Twitter by students limits its application in educational settings (Lin, Hoffman, & Borengasser, 2013).

The focus in the literature on digital backchannels in higher education contexts has thus shifted to specialized backchannels due to the possibility of students asking questions anonymously, the engagement being limited to real-time in the class and not saved thereafter or publicly accessible, as well as the potential for custom-built design. Due to the early stages of these developments much work has gone into software design and some researchers have carefully documented each stage of this process (see especially the documentation on the development of the 'Backstage' package: Baumgart, Pohl, Gehlen-Baum, & Bry, 2011; Gehlen-Baum, Pohl, & Bry, 2011; Pohl, Gehlen-Baum, & Bry, 2012). The basic idea of a specialised backchannel is that students working from a device can (usually anonymously) post text to a website that is either projected onto a screen in the class or available on the lecturer's desk. The following are additional features that have been incorporated in software and found to be of use:

- Ability for students to 'like' (or 'dislike') posts (Aagard, Bowen, & Olesova, 2010; Bergstrom, Harris, & Karahalios, 2011; Holzer et al., 2013; Pohl et al., 2012)
- Use of icons to signal different types of contributions (Bergstrom et al., 2011; Holzer et al., 2013; Pohl et al., 2012)
- Ability for the lecturer or teaching support staff to moderate posts (Holzer et al., 2013)
- Ability for students to give feedback on lecture pacing (Pohl et al., 2012)
- Improving ease of access via multiple devices and without the need to create an account (Aagard et al., 2010; Ratto, Shapiro, Truong, & Griswold, 2003)

There is also some work in integrating backchannel software into existing classroom management systems and thus allowing this to work alongside classroom response systems (where lecturers pose questions to the class) and delivery of lecture slides (Pohl et al., 2012). For the purposes of this study, however, we focus specifically on the backchannel software.

An emerging literature goes beyond software evaluation to consider the educational impact of incorporating the backchannel, in terms of classroom dynamics and individual student and lecturer experiences. Some of these studies describe themselves as pilot testing of the software in experimental settings (Pohl et al., 2012) – here students from a range of academic backgrounds were recruited for a study which (notably) took place in a computer laboratory with all students logged

in to the backchannel software. Others are of short duration but tested in a real class setting (Bergstrom et al., 2011; Holzer et al., 2013) – notably Bergstrom et al. compare classroom behaviour before and after the introduction of the backchannel. Studies of longer duration are those by Du et al. (2012) conducted over 14 weeks and by Ratto et al. (2003) over 10 weeks. It must be noted that students in the Du et al. study were offered extra credit for participation. Yates, Birks, Woods, and Hitchins (2015) report on the introduction of a backchannel into a nursing course that was run across multiple sites. The study however mainly reports on student evaluation of the activity, with limited data from classroom observations. Aagard et al. (2010) offer what is possibly the most extensive study to date, spread over two semesters and across a number of large classes in the same institution.

A key focus for this research has been whether students take up the opportunity to use the backchannel, and how this alters the overall question-asking patterns in class. Pohl et al.'s (2012) experimental study showed approximately three times more questions were asked in the experimental group compared to the control group. Bergstrom et al. (2011) in their real class setting found that only a small number of users actually used the software – although it should be noted that only 20% of the class had the required hardware. Holzer et al. (2013) again noted that participation was limited by hardware, although they reported just less than half the class using the backchannel. This study did show that the 'like' feature had greater take-up than the asking of questions, although they found that organizational messages, such as requesting lecture slides or asking for a light to be turned on were 'liked' the most out of any other type of posting. Messages relating to actual course content were rated less frequently.

The study by Du et al. (2012) showed much higher levels of participation but this is not surprising given the course requirement to participate; even here participation was high at the start of the study but tapered off through the semester. Ratto et al. (2003), while also noting the limited take-up of the backchannel (once the novelty had worn off, about one third of students participated) also note the limitations of a study focus merely on participation – typically there will be at least *some* participation even if at a low level – and thus it is worth considering other aspects that have been explored in these studies.

Thus an emerging area of research looks at the content of backchannel contributions. Pohl et al. (2012) in their experimental study found limited off-task content, some feedback, and that the largest proportion of contributions were questions – noting however that a majority of questions represented a lower-order style of thinking. Bergstrom et al. (2011) categorised responses as either on-task or off-task, and found that the latter were sufficiently prominent that they did on occasion disrupt the lecture. Holzer et al (2013) found a fairly high proportion of 'irrelevant' content early on after the introduction of the backchannel, but found that this declined over time, possibly at least partly due to the lecturer having discussed this issue in class. Du et al. (2012) provided a comprehensive classification of the range of responses that were made through the backchannel: 19% of backchannel activity was questions; most of the contributions were students commenting on their peer's work; notably 28% of the activity was on conversations not related to the classwork. Ratto et al. (2003) found that the questions that students posed were of a higher standard than previously noted. The backchannel also resulted in a broader range of questions and the lecturers indicated that they found these useful.

Another new area of research looks at *which* students in the class are using the backchannel and considers how this might or might not be related to academic performance. Aagard et al. (2010) found that in two of the three classes where they implemented a backchannel, there was a correlation between the number of posts via the backchannel and course grade – those who used the software tended to be those who obtained higher marks.

A final focus is on students' attitudes towards the backchannel. Even in settings with low uptake, students are enthusiastic about the idea of the backchannel and support its adoption across more courses (Bergstrom et al., 2011; Holzer et al., 2013; Yates et al., 2015). A related area of investigation considers the lecturer's response to the presence of a backchannel and here again lecturers were mostly positive about the advantages of having this tool in their lectures (Aagard et al., 2010; Bergstrom et al., 2011). On the other hand, and building on the broader literature on the presence of connected devices in the classroom (Fried 2008, Junco 2012), some backchannel studies have suggested that the presence of the backchannel and the consequent presence of mobile phones in the class might contribute to distraction (Aagard et al., 2010).

Building on this overview of the literature, we thus sought to test these emerging findings in the naturalistic setting of a third year chemical engineering course in a South African university. Specifically, we aimed to determine:

- How the backchannel affected the total number of questions asked;
- The nature of the interaction that took place in the class using the backchannel;
- The level of participation in the class as a consequence of the introduction of the backchannel;
- If the backchannel was a disruption to the lecturer; and
- If the backchannel was a source of distraction to students.

3. Methodology

3.1. Development of the software

A key factor considered in the application design was the accessibility of the backchannel. By reducing the barrier to entry, as well as the administration required to operate the backchannel, it is likely to result in more students and lecturers using the

software. 'Engage' was therefore built to be accessed through an internet browser rather than an application that needed to be installed on students' laptops. There are a large number of different devices that utilize internet browsers and thus 'Engage' was designed to render usefully on all screen sizes, ranging from mobile phones to tablets and laptops. Screenshots of the software are given in Figs. 1 and 2.

Drawing on the literature outlined earlier, the software was developed to include a wide range of features such as the ability to ask questions anonymously, the option to 'like' posts, as well as the option for a lecturer to moderate what is seen by other students. Additionally, further functionality was added to allow students to signal the following kinds of feedback:

- A 'Lost' button which students click when they are lost in the lecture
- A 'Slow-down' button designated by a tortoise icon
- A 'Speed-up' button designated by a springbok icon

The latter two responses were used to create a 'gauge' which displayed on the lecturer's screen. An additional feature that was added to the lecturer panel was an indicator that alerted the lecturer when a question had reached a certain number of votes. For this report, a 'ping' was initiated when a question reached ten votes. The ping was a graphic animation of concentric circles becoming larger, designed to draw the lecturer's attention to what would be a pertinent issue. This 'ping' happened continuously until the lecturer had acknowledged the question by moving the computer mouse.

3.2. Study participants and setting

This case study focused on a third-year chemical engineering course on reactor design at the University of Cape Town, with two sections of work delivered by two different lecturers, referred to as Lecturer 1 and Lecturer 2. The course had just under 100 students enrolled and ran over 12 weeks with four 45 min lectures per week; the study followed 14 consecutive lectures from about mid-way through the course. The course also had a weekly tutorial session in which students worked at their own pace on problems; the backchannel was not used during these sessions.

Students were informed about the project at its outset and advised that participation was voluntary. No additional credit was offered to students for using the backchannel. All backchannel data was logged anonymously. Students were invited to complete the surveys and some were invited to focus groups; all this participation was voluntary.

In order to determine how the backchannel influenced the class dynamics, it was important to observe the class before the backchannel was implemented (following the method of Bergstrom et al., 2011). Thus, for Lecturer 1's section, the class was observed for four lectures without a backchannel, and then for four lectures with the backchannel. There was then a changeover in lecturers, where Lecturer 2 would lecture the course for six lectures. The class was observed without a backchannel for two lectures and then the backchannel was implemented for a further four lectures. This research design allowed for the comparison of the class dynamics with a backchannel present as well as without, but importantly also to follow closely its implementation by two different lecturers.

3.3. Data collection and analysis

In order to increase the reliability of the results, a mixed-method approach to data collection was used in this study (Borrego, Douglas, & Amelink, 2009). The study took place in a naturalistic setting (Lincoln & Guba, 1985) and thus it was

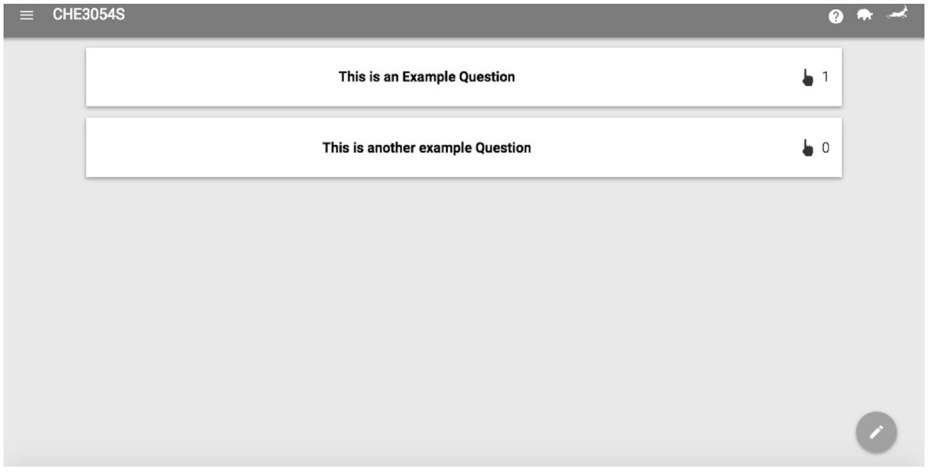

Fig. 1. Projected screen of backchannel interactions.

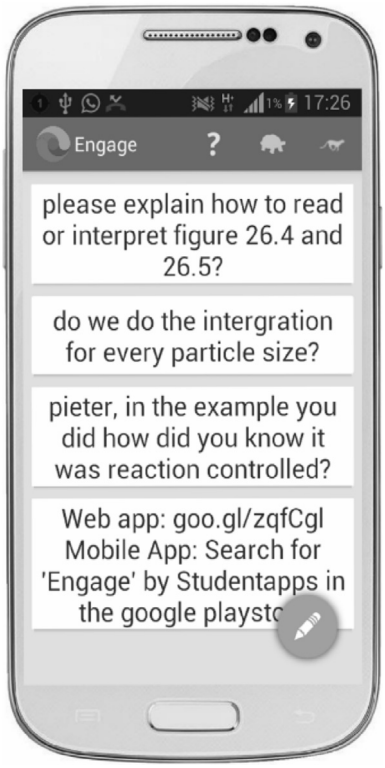

Fig. 2. Student interface.

considered appropriate to have a combination of quantitative and qualitative data. Case and Light (2014) provide an elaborated argument for the value of bringing in qualitative analyses alongside quantitative in engineering education research. In this study, the backchannel offered automatic logging of questions on a time basis and thus generated a mass of quantitative data; recording of questions allowed qualitative analyses to be performed on question content. To obtain student perceptions, two strategies were adopted: firstly a survey to get a broader impression of the class views, secondly a series of focus groups to generate more in-depth data. The former lent itself to a simple quantitative analysis and the latter to a qualitative analysis. Lecturers were interviewed before and after implementation of the backchannel and these data were analysed qualitatively. Finally, observational notes were kept throughout the class and these offered context particularly for the backchannel data.

The first two authors were responsible for collecting and analysing the data associated with this project and the second two authors acted as independent checks on the emerging analyses. The mixed-methods research design allowed for some degree of 'triangulation' across the data sources. Further details on the collection and analysis of the five sources of data are given here:

a. Backchannel data: Backchannel activity was logged automatically with particular emphasis on individual user profiles. The backchannel logged interactions automatically. However, the fact that students did not log in to the backchannel meant that if an individual used multiple devices, the devices could not be linked to this person. This means that the exact number of users could not be determined with absolute confidence. However, this was partially corrected in the final survey, by asking students on how many devices they used the backchannel, and scaling the results appropriately. The quantitative data were summarised in graphical form.
b. Student Surveys: Two surveys were conducted, one before the backchannel was implemented in the classroom and one at the end of the trial. These were designed to assess students' participation habits, and attitudes towards class participation in general as well as views on the backchannel. The surveys consisted almost entirely of closed questions with Likert scale ratings and are reproduced in full in Appendix A. Given the size of the sample (pre-survey $n = 57$, post-survey $n = 39$) only descriptive statistics were performed on these data.
c. Student Focus groups: Three carefully constructed focus groups (Wilson, 1997) were conducted. This data source was used to ascertain the students' thoughts about the backchannel as well as lectures in general. We aimed to create three different focus groups, with a range of backchannel usage patterns and attitudes towards asking questions verbally. Individuals were selected based on their observed backchannel and verbal behaviour in the classroom environment, and were then personally approached and invited to participate. We then requested that they recruit a few of their friends in the class to participate. The resultant focus groups had the following characteristics:

- Focus Group 1 – students who did not use the backchannel very often and were comfortable asking verbal questions (n = 4).
- Focus Group 2 – students who did use the backchannel and were moderately comfortable asking verbal questions (n = 5).
- Focus Group 3 – students who did use the backchannel and were uncomfortable asking verbal questions (n = 4).

The focus groups ran in a semi-structured format and focused on getting students to talk broadly about their experience of the course, and then specifically about their experience of the backchannel. Focus group data was analysed using content analysis, which involved identifying different themes in the data and coding all data accordingly (Miles & Huberman, 1994; Strauss, 1987).

d. Lecturer Interviews: Each lecturer was interviewed before and after the implementation of the backchannel in order to assess their attitudes towards using this tool as well as general class dynamics. All interviews were semi-structured (interview protocols are given in Appendix A) and conducted by the first two authors. The data were analysed using a content analysis as described above.
e. Observational notes: The first two authors sat at the back of the class and took field notes regarding the number and type of verbal questions, as well as any other interesting happenings in the class. Particular emphasis was also placed on determining the context of backchannel activity. Observational data were used to supplement the findings from other data sources.

4. Results

4.1. The effect of a backchannel on the total number of questions asked during a lecture

In order to determine the effect of the backchannel on the total number of actual questions asked during the 45 min lecture, the number of questions asked without the backchannel present was first established. Table 1 below indicates the number of questions asked of each lecturer during the observation period as well as the number of questions that each lecturer estimated that they typically receive during a lecture (asked in the interview, see Appendix A). Reference to these data suggest that the observed number of questions is indicative of the number of questions that the lecturers expected to typically receive.

Fig. 3 illustrates the number of questions asked during lectures both through the use of the backchannel as well as through the more traditional verbal approach. The total number of questions (including backchannel and verbal) increased during the lectures when the backchannel was implemented. The boxes included in the figure identify those lectures when the backchannel was not used while the large black dots in the figure indicate the combined number of questions. This result is supported by Lecturer 1 who said in their post-project interview that “there were more questions asked [in total] with the backchannel than without” (Lecturer 1, l53).

Fig. 3 shows that the patterns of interaction are highly variable. Using our observations notes from class we noted how the patterns of question asking (both verbal and backchannel) were highly dependent on the content of a particular lecture, with the introduction of new and challenging content being particularly promotive of question-asking. As noted above, Lecturer 1 tended to elicit more questions in her conventional teaching and to some degree this pattern carried over into the backchannel mode. Lecturer 2 tended to have fewer questions posed but in one lecture (number 12) he asked the students to use the backchannel for a question he had posed, hence the spike in interactions at this point.

In the post-survey (n = 39, see Appendix A) we explored the reasons why students might not verbally ask questions in the traditional class environment. Fig. 4 shows that there are a number of students who agree (36%, n = 14) that they are concerned that they will look foolish when asking a question while 2% (n = 1) strongly agree with this position and 28% (n = 11) are non-committal. This suggests that almost two thirds of students are influenced by how asking a question in class would potentially be seen by their peers. This explains why an anonymous backchannel might allow for more classroom interaction as illustrated by Fig. 3.

4.2. The nature of the interaction that took place in the class using the backchannel

The above analysis only focused on question-asking. This however formed a small minority of all logged interactions that students had with the backchannel software. Categorising and counting interactions yielded the findings shown in Fig. 5 with categories as follows:

Table 1
Comparison of the actual number of observed questions with the number of questions the lecturers expect to typically receive during a lecture.

	Class observations (Questions per lecture)	Lecturer interviews (Anticipated number of questions)
Lecturer 1	3, 9, 12, 11	10 – 15
Lecturer 2	2, 5	4 – 5

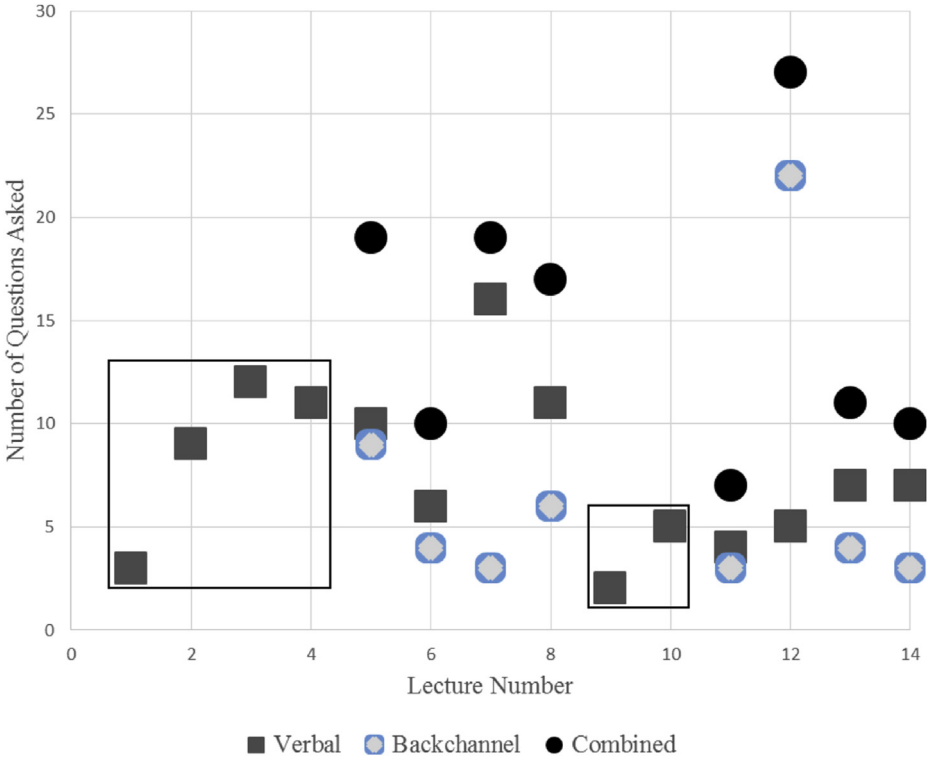

Fig. 3. Plot illustrating the number of questions asked verbally as well through the use of a backchannel.

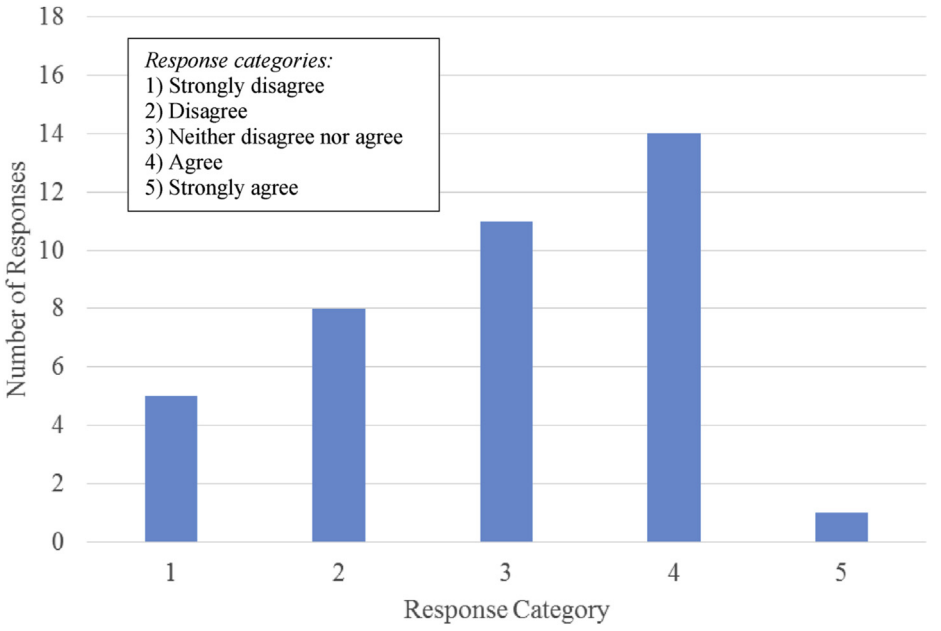

Fig. 4. Survey data illustrating the response to the question "I am concerned that I will look stupid when responding to a question (without the backchannel)".

- Questions: Students used the software to ask questions in various ways (17%, n = 52)
- Votes: Students 'voted up questions posted by their classmates that they 'liked' (70%, n = 220)
- Losts: Students used the backchannel to indicate that they were 'lost' (4%, n = 14)
- Students commented on the pace of the lecture using the backchannel:
  - o Speed-up: Some comments focussed on asking the lecturer to 'speed up' (6%, n = 18) [speed-up]
  - o Slow-down: Some comments focussed on asking the lecturer to "slow down" (3%, n = 10)

It can be seen that 'voting' formed the overwhelming majority of student interactions. Question-asking, while far less prominent, also was more common than the remaining categories of interaction. Given the predominance of voting and asking, in the post-survey (see Appendix A) we specifically asked students for their views on these features of the backchannel. The results are given in Fig. 6. In general students found both of these features useful in supporting their learning in class.

Given that asking questions or asking the lecturer to slow down or speed up are interactions that can also be carried out in a traditional classroom, during the pre-survey (n = 57), specific questions were asked that related to how students engaged with a lecturer during a class. Students had to respond using a five-point Likert scale and selected results are shown in Fig. 7.

The data in Fig. 7 show that students do not typically ask a lecturer to speed up their lecturing pace ($\bar{x}$=1.11, σ = 0.31, n = 57), nor do they ask a lecturer to slow down ($\bar{x}$=1.19, σ = 0.44, n = 57). There is a bit more of a spread relating to whether students ask questions in class, but even there, the mean response is 2.24 (σ = 1.11, n = 57) – students very rarely or only occasionally ask questions in class.

4.3. The impact of the backchannel on participation in lectures

In this section we return to a focus on question-asking. While this only formed 17% of the backchannel interactions, as noted earlier the overall number of questions asked in class increased notably when the backchannel was introduced. We were therefore interested to determine whether it was only the same students who typically asked verbal questions were now also using the backchannel or whether the backchannel had introduced 'new' participants to question-asking. We thus needed to estimate a number of students that were associated with the backchannel questions and this involved several steps of estimation since the backchannel logging was anonymous, and while it recognised individual device IDs we knew that some students used more than one device.

Firstly, from the backchannel log it was determined that out of the 75 devices accessing the backchannel, only 24 devices used it to ask questions. To link this to an estimated number of students we determined a device:student ratio from the responses (n = 39) to Question 6 in Part A of the post-survey (see Appendix A). Here 67% of students said they accessed the backchannel through a single platform, 15% said they used more than one platform and the remainder did not use the backchannel. This resulted in an estimate of 1.2 devices per student using the backchannel, which allowed us to convert the 24 question-asking devices into an estimate of 20 students. Given that our field observations showed a maximum of 15 students who asked questioned verbally in class, we estimate a small additional number of students (in the order of 5) who were now asking questions via the backchannel – this is assuming that those who asked verbal questions also asked them via the backchannel.

The suggestion from these quantitative analyses that there were additional students who didn't ask questions verbally but were doing this via the backchannel is triangulated by drawing on a number of sources of qualitative data. Both lecturers suggested during their post-project interviews (see Appendix A) that they experienced 'backchannel' questions as being asked by a different set of students; Lecturer 2, for example, indicated that they felt that many of the questions posted on the backchannel were not from the 'usual' group of verbal question askers (Lecturer 2, l61). This observation by the lecturers was borne out by the field notes collected during the study: these notes indicated that there were students identified who used the backchannel to ask a question when they had not asked a question verbally throughout the study. Furthermore, some students in the focus groups indicated that while they may not have asked verbal questions they did make use of the backchannel to post their queries. These students also indicated that they had seen their peers asking questions through the backchannel who they knew not to have asked any questions verbally (Focus Group 2, l32).

The post-survey survey undertaken (n = 39) showed an increase in the number of students whose frequency of participation altered with the addition of the backchannel. 41% (n = 16) of students indicated that they asked a *question* with the

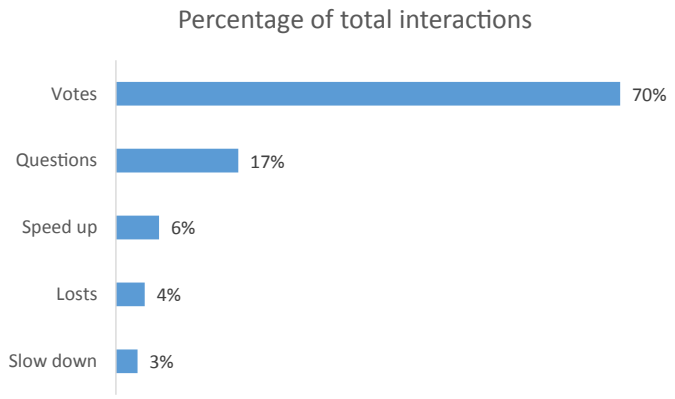

Fig. 5. Way in which students engaged with the backchannel software.

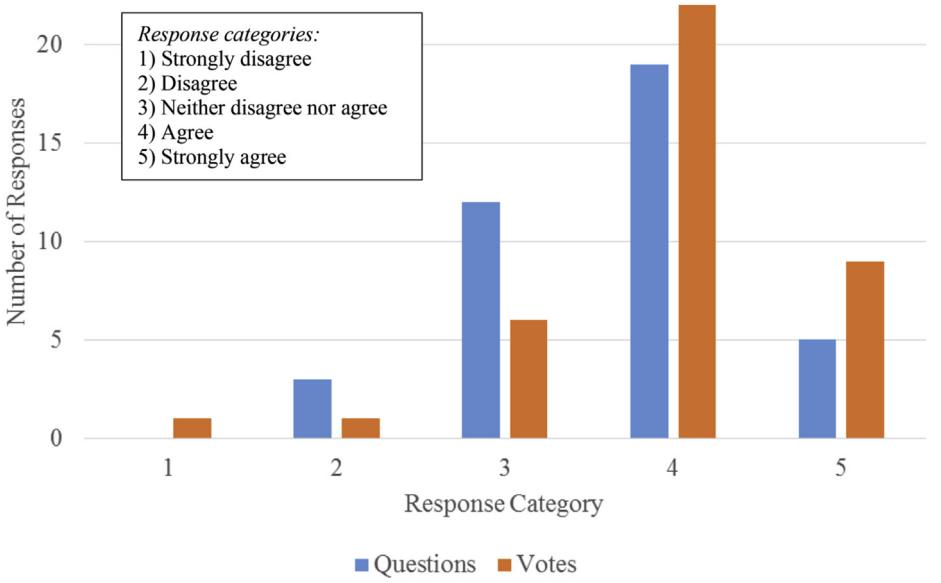

Fig. 6. Survey data indicating whether students felt that the ability to ask and to vote on questions was helpful to their learning.

backchannel once every few lectures; 90% (n = 35) of the students indicated that they used a backchannel *feature* at least once every few lectures, with 54% (n = 21) indicating that they use a *feature* at least once a lecture. This can be compared to the data presented in Fig. 5 where students indicated that they very rarely or only occasionally ask questions in class – let alone ask a lecturer to speed up or slow down their lecture.

4.4. Lecturer's experiences of using the backchannel

The qualitative data collected were analysed to investigate the potential for this backchannel technology to distract the lecturer from being able to focus on engaging with their class in a traditional way. During their interview (see Appendix A), Lecturer 2 suggested this additional interaction can take up to five minutes from a lecture (Lecturer 2, l112), as it takes time to satisfactorily address the backchannel questions that are posted.

There was an additional concern expressed by students in the focus group that if too many people wanted the lecturer to 'slow down', that this could create time pressure with respect to completing the material in the course. Several students in the focus groups also expressed concern that they thought the backchannel was 'stressing the lecturer out'. In particular, one student felt that Lecturer 2 could potentially 'freak out' (Focus Group 2, l58) when the 'lost' dial increased flagging that many students were not following what was being presented. The field notes collected during this lecture did not suggest this situation to be an issue, and during their interview, Lecturer 2 indicated that he did not find this dial distracting at all (Lecturer 2, l137).

In general, we found that the lecturers enjoyed the use of the backchannel. In particular, they reported that they appreciated the instantaneous feedback on their lectures, as they found it typically difficult to assess if students are actually understanding the course material during lectures. As an example, Lecturer 1 commented during an interview:

"You are often responding to people who are either asking the questions. Even though you are teaching to the whole class, you are seeing the people at the front far more who tend to be the keen people. If they are nodding (the people in the front) you sort of go "Okay, I'm getting it". But there may be people at the back that might be struggling. So I found that very useful and I think that is something I would want to keeping on having available."

Similarly, Lecturer 2 said that he particularly enjoyed the immediate feedback of obtaining questions after explaining a concept. And that the speed gauge was particularly helpful as it is typically difficult to discern if the pace of a lecture is correct based on the facial expressions of students.

4.5. The potential for distracting students

Drawing on the preliminary survey data (see Appendix A) obtained from the students at the beginning of the project (before the backchannel was introduced) and using a five-point Likert scale with the following response categories: 1) Strongly disagree, 2) Disagree, 3) Neither disagree nor agree, and 4) Agree, 5) Strongly agree, students indicated that their phone or laptops were a source of distraction during lectures ($\bar{x}$=3.79, σ = 1.27, n = 57). They also indicated – using the Likert

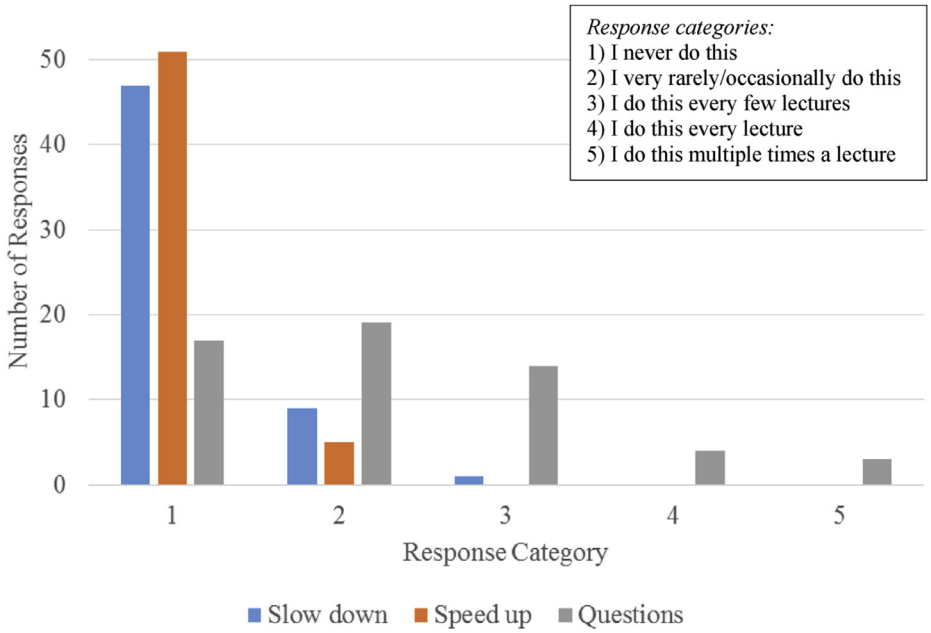

Fig. 7. Survey data indicating how students verbally engage with a lecturer by "asking questions", "asking them to slow down", and "asking them to speed up".

scale that included the response categories 3) I do this every few lectures, and 4) I do this every lecture – that they looked at their phone for non-academic reasons (excluding looking at the time - $\bar{x} = 3.54$, $\sigma = 1.16$, $n = 57$). These data show that there are a number of students who are distracted multiple times during a lecture. It is likely that these results are underreported as Kraushaar and Novak (2010) have argued that students tend to under-report email and Instant Messaging usage – common distractions – by 7% and 40% respectively.

The analysis of the qualitative data that emerged from focus groups one and two suggest however that the backchannel software did not itself distract the students. Focus group three indicated that the backchannel was a "slight distraction" (Focus Group 3, l176), but on interrogation, this related to an occasion where a joke was posted to the backchannel during the first backchannel lecture. This notwithstanding, the surveys revealed that a small group of students (18%) did find the backchannel distracting. This included students who also suggested that the 'shuffling' (Focus Group 2, l514) of questions on the screen could be somewhat distracting.

Fig. 8 shows the results from two questions asked during the post-survey of students ($n = 39$), namely whether the backchannel distracted the students during the class, as well as whether the students felt that the backchannel software helped them focus on the lecture taking place.

In the classroom, the backchannel was utilized in two modalities: firstly by having the lecturer display the questions being posed by the class on their personal laptop, and secondly by projecting the output of the backchannel onto a screen. Lecturer 2 found that the projected backchannel was not distracting to the students, as he felt it was simply "sitting in the background". The focus groups showed that the vast majority of students preferred the backchannel to be projected onto a screen with focus group comments saying that "it works better on the screen", "it's a nice way to keep everyone engaged", and "it helped create a sense of a community". As suggested earlier, this was also helpful for students who did not have access to the backchannel software. We argue that the addition of projection did not unduly add to the distraction of the class from the teaching and learning activities taking place and in fact a relatively large group of students found that it actually helped them focus on the course material.

5. Discussion

The results of this study provide a close-up analysis of the contribution that the introduction of a backchannel can make to both the teaching and learning that takes place during a lecture. The course from which the data was drawn is broadly representative of engineering courses in general and the data was collected from a range of different sources which has allowed some valuable insights to emerge.

One of the most important results from this study was the widespread use and popularity of the 'like' feature of the software, allowing students to 'vote' on questions that had been posted via the backchannel. It was ranked as the most helpful backchannel feature to help students engage with the course material in a survey of the class. This feature is something that is not, and arguably could never be, part of a traditional lecture structure. To quote a participant in a focus group: "In a lecture

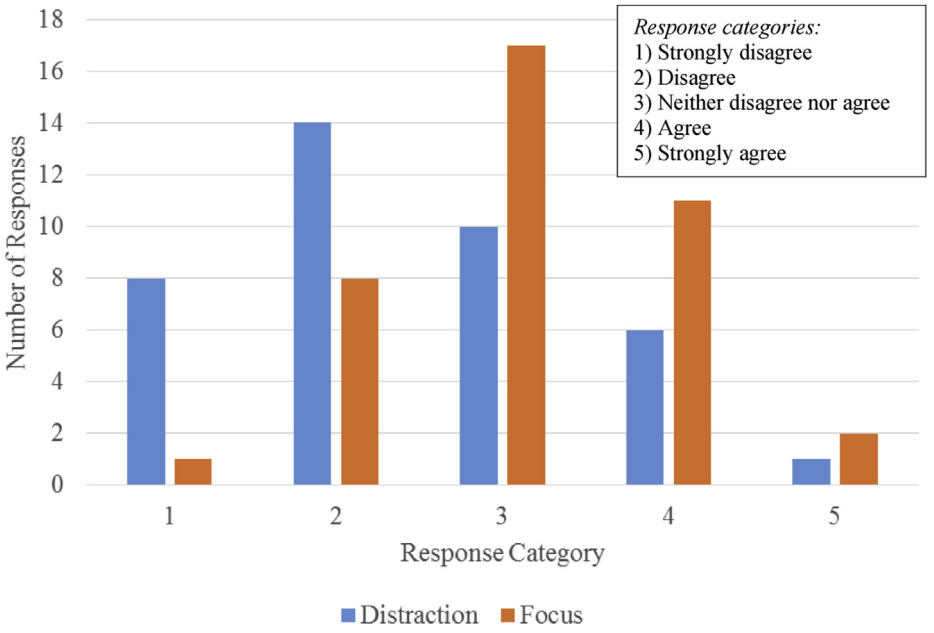

Fig. 8. Survey data showing the response to the questions: "the software distracted me from the lecture" and "the software helped me focus on the lecture".

you can't say: 'That's a good question, can you answer that please?'". The popularity of the 'like' feature is maybe not that surprising due to the widespread use of a similar function on social media platforms such as Facebook, although it should be noted that this could be seen as a relatively passive form of in-class engagement. The focus groups revealed though that students tried to answer backchannel questions themselves, before the lecturer did, in order to test their own knowledge, and then 'liked' the question if they could not answer it; in other words students 'didn't always know that [they] had a question, until [they] saw it' (Focus Group 1). In this way, students were taking quizzes, and asking for help if they could not provide their own answer. This is similar to the philosophy employed by an audience response system which forces students to engage with material by answering a relevant question. However, in the case of the audience response system, the question is set by the lecturer, and involves the lecturer allowing students time to try answer that question. A backchannel constitutes a similar type of tool, but it is argued that as these questions are coming from peers, they may actually be more valuable than a question posed from the lecturer since it gives a lecturer a clear indication of what concept(s) students are struggling with. From the student perspective, students may be meaningfully engaging with material relatively often: If a question appears every 10 min, students are forced to test their newly acquired knowledge regularly, and can easily obtain an answer if struggling. When a concept is first introduced to a student, individuals may interpret it differently, leading to different questions being posed on the backchannel. By seeing peers' questions, learners have the potential to view other peoples' thinking – as well as their difficulties with the concepts being presented.

Many backchannels focus on the opportunity to ask questions; indeed, many specialist applications only offer this functionality. Based on the outcome of the analysis undertaken, the ability to 'vote' on the questions posed, as well as being able to comment on the pace of a lecture, are useful additions to the backchannel. This study has shown that backchannels should not be viewed as simply allowing more reserved students to voice questions. It offers students novel methods of participation that benefits all types of students as well as lecturers. Furthermore, we would argue that a backchannel activity can lead to a group of students interacting with each other, and the lecturer, to grapple with and understand difficult concepts. This form of engagement has, in this study, resulted in some students claiming they are now more comfortable asking questions verbally and will do so in the future even though the backchannel may no longer be used in the course. The survey data indicated that the majority of those students who were uncomfortable asking questions verbally were concerned with how they would appear in front of their peers. Through the use of the backchannel we argue that these students have realized that their peers may be equally confused, and the perceived social barrier to participation has thus diminished.

In comparison to the other research into backchannels, this study found that, with the introduction of the backchannel, more questions were still asked verbally than through the backchannel. This result is in agreement with the studies of Bussières et al. (2012) and Bergstrom et al. (2011), but has a different finding to that of Pohl et al. (2012). All the same, our results do show that in this context the introduction of a backchannel has measurably increased the overall number of questions asked during a lecture. Compared to Bergstrom et al. (2011) and Holzer et al. (2013) we did not note that hardware posed any limitation on student participation in the backchannel. We also, unlike Ratto et al. (2003), did not note a drop off in interest over time although the use of the backchannel fluctuated from lecture to lecture. And unlike Du et al. (2012) we found relatively limited off-task behaviour.

Students made relatively limited use of the 'speed-up' or 'slow-down' feature on the backchannel, a potentially awkward verbal request which was thought might be more popular in its anonymous backchannel form. The contexts under which these requests were made, however, suggests that students used this form of feedback sensibly, in a manner that was useful to them. It was found that students tended to ask the lecturer to 'speed-up' when going through relatively simple examples – they wanted more lecture time to deal with more complex topics. Similarly, students tended to ask the lecturer to 'slow-down' when new and potentially confusing topics were introduced.

The backchannel – at times – seemed to act as an icebreaker. As questions were posted on the backchannel, students could see what their peers were thinking in real-time. As a result, the backchannel made people feel that they were not alone in their confusion. This was shown in lecture eight, where, after noticing that the 'lost' dial had reached 8 people, the lecturer asked the class where they were confused. Students then started to raise their hands, explaining their problems.

Based on the work of Junco (2012) and others (for example, Ragan, Jennings, Massey, & Doolittle, 2014), it is clear that students having access to laptops in class has the potential to detract from learning in lectures. Smartphones present a similar, if not more severe problem, due to their mobility, ubiquity and the ease with which they allow users to communicate with others. Indeed, some educators have banned laptops in their classrooms, as they believe that they are simply too distracting for students (Rockmore, 2014, National Post, 2015). The first survey conducted in this study showed that the majority of the class felt they were distracted by their phones or laptops in the conventional lecture, with a portion of them distracted multiple times a lecture. However, using a backchannel allowed students a simple, practical way in which to use these technologies effectively. Although, while a backchannel did help a group of students focus on the lecture, the data from the focus groups revealed that some students had the backchannel in a browser tab, and would alternate between Facebook (or other non-academic activities) and the backchannel. However, other students revealed that they simply left the backchannel open on their phones or laptops, essentially 'locking' the device on this tool, eliminating further distraction.

6. Conclusion

To date there has been relatively little research on the potential impacts of a backchannel on classroom interaction. The significance of the present study lies in a number of aspects. Firstly, the backchannel software developed carefully incorporated a full range of features to promote interaction – in this regard the study found that the 'like' icon was particularly well used and appeared to promote good engagement across a lot of the class, not only the question-askers. With regard to who was using the backchannel, the study used a range of sources of evidence to suggest that a broader range of students asked questions as a result of the software. The fact that students could also comment on the pace of the lecture was considered highly valuable, and a particular group of students, mostly those comfortable with asking verbal questions, considered this feature to be the most valuable of the backchannel's functionality.

Methodologically the study has pointed to the value of a naturalistic inquiry in a real course setting with no external inducements for participation. The small sample size did not allow for statistical analysis but the use of mixed methods allowed for some degree of triangulation across sources of evidence. It is clear that further research is needed in this area to allow for elaboration of the findings emerging in this study – specifically it will be important to investigate more closely the nature of questions that are asked via the backchannel, the impact of 'voting' on student learning, as well as the possibility for either reducing or increasing distractability.

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Appendix A. Survey Questions

Pre-Survey

Part A

Please evaluate the following statements using the scale below from a PERSONAL point of view. Where,

1: Strongly disagree
2: Disagree
3: Neither agree nor disagree
4: Agree
5: Strongly agree

1. I find lectures helpful to my learning of the course material
2. I am comfortable asking questions during lectures
3. I am comfortable responding to questions posed by the lecturer during lectures

4. I am concerned that I will look stupid when asking a question
5. I am concerned that I will look stupid when responding to a question
6. I am comfortable asking the lecturer to slow down
7. I am comfortable asking the lecturer to speed up
8. I am concerned that I will look stupid when asking the lecturer to slow down
9. I am concerned that I will annoy my peers by asking the lecturer to speed up
10. My phone or laptop is a source of distraction for me during lectures

Part B

Please evaluate the following statements using the scale below from a PERSONAL point of view, for your AVERAGE lecture for THIS COURSE with THIS LECTURER ONLY. Where,

1: I basically never do this
2: I very rarely/occasionally do this
3: I do this every few lectures
4: I do this every lecture
5: I do this multiple times a lecture

1. I ask questions
2. I respond to questions posed by the lecturer
3. I am distracted during a lecture
4. I look at my phone for non-academic reasons (excluding looking at the time)
5. I ask the lecturer to slow down
6. I ask the lecturer to speed up

Part C

Please answer the following questions:

1. What is your age? (please include half years)
2. What is your first language/What is the language spoken to you most by your parents?
3. What is your gender?
4. Do you own a laptop?
5. Do you own a cellphone with internet access?
6. Do you own a smartphone?

Part D

Are there any comments that you would like to add?

Post-Survey

Part A

Please answer 'yes' or 'no' to the following statements:

1. I have an android phone
2. I installed the android application
3. I used the android application
4. I have an internet-enabled device
5. I used the web application
6. If yes to 5, I used the web app on
   a. phone
   b. laptop
   c. tablet

Part B

Please evaluate the following statements using the scale below from a PERSONAL point of view. Where,

1: Strongly disagree
2: Disagree

3: Neither agree nor disagree
4: Agree
5: Strongly agree

1. I am comfortable asking questions during lectures (without the backchannel)
2. I am concerned that I will look stupid when responding to a question (without the backchannel)
3. I am comfortable commenting on the lecturer's pace (without the backchannel)
4. I am comfortable asking questions using the backchannel
5. As a result of the backchannel, I engaged more in the course material
6. The backchannel is helpful to my learning of the course material
7. Asking questions with the backchannel is helpful to my learn-ing of the course material
8. Being able to vote on other people's questions was helpful to my learning of the course material
9. Being able to comment on the pace of the lecture, or say when I was lost was helpful to my learning of the course material
10. The software distracted me from the lecture
11. The software helped me focus on the lecture
12. I preferred the backchannel to be projected on a screen
13. I would like the use of this software to continue in this course
14. I would like the use of this software to continue in other courses
15. With some adjustments, I would want the use of this software to continue (if so, please mention these adjustments in PART D)
16. If the software was not used further, I would ask more questions than I did before the software was implemented

Part C

Please evaluate the following statements from a personal perspective, for your average lecture where the backchannel was operational, using the scale below:

1. I basically never do this
2. I very rarely/occasionally do this
3. I do this every few lectures
4. I do this every lecture
5. I do this multiple times a lecture

1. I used the software in any form e.g. asking a question, liking a question, speed up, slow down, 'I'm lost'
2. I asked a question without using the backchannel i.e. through voice
3. I asked a question using the backchannel
4. I responded to questions posed by the lecturer using the backchannel
5. I 'liked' a question using the backchannel
6. I asked the lecturer to slow down, using the backchannel
7. I asked the lecturer to speed up, using the backchannel
8. I told the lecturer I was lost using the backchannel (only assess this question for Dr Grant's section)

Part D

Are there any comments that you would like to add?

Interviews

Preliminary interview questions:
1. Why were you keen to be involved?
2. Do you think that lecturing needs to improve generally? And for this course in particular?
3. Do you think there is a need for digital back channels?
4. How are you currently finding the interactivity in this class?

a. Is there a select group of students who ask questions? If so, numerical estimate?
b. How are questions with respect to time? Are they spaced evenly throughout the lecture or do they occur in clusters?
c. How many questions are normally asked during a lecture
d. What type of questions are usually asked?

5. Do you think the addition of a back channel would be helpful?
6. How do you intend to use the back channel? If you have any intentions?

7. How do you feel about process orientated feedback vs. content orientated feedback?
8. Do you ever feel that you lose control with the class? How do you re-gain control?
9. Do you ever get distracted while lecturing? If so, how do you recover?
10. Do you have any major concerns over the use of the back channel?

Post-backchannel interview questions:

1. Tell us about your experience with the backchannel. What worked? What didn't?
2. Do you think the engagement changed? If so, in what ways?

a. Side note – try ask who the lecturer thinks was using the backchannel

3. Do you think more questions were asked than without the backchannel? If so, can you give us any numerical estimate?
4. What did you think about the type of questions asked via the backchannel?
5. How did it affect your lecturing?

a. Did it distract or disrupt
b. Did it slow down the lecture i.e. was too much time spent addressing the backchannel?

6. What did you think about the speed gauge? Do you think that people commenting on pace is valuable?
7. Would you continue using a backchannel in lectures? Why?
8. Would you continue using the software? Why?

a. Side note – try guide the lecture to ensure that the software is also rated

9. Stimulated recall

a. There was a question asking why the order of mixing was important in reactor design. This is a fundamental question for this topic and even reactor design. It got 6 votes overall. What do you think about the fact that someone asked that and that it was quite popular?

10. Anything else that you would like to add?

References

Aagard, H., Bowen, K., & Olesova, L. (2010). Hotseat: opening the backchannel in large lectures. *Educause Quarterly, 33*(3). Retrieved from http://er.educause.edu/articles/2010/9/hotseat-opening-the-backchannel-in-large-lectures.

Baumgart, D., Pohl, A., Gehlen-Baum, V., & Bry, F. (2011). Providing guidance on Backstage, a novel digital backchannel for large class teaching. Retrieved from https://epub.ub.uni-muenchen.de/14915/1/bry_14915.pdf.

Bergstrom, T., Harris, A., & Karahalios, K. (2011). *Encouraging initiative in the classroom with anonymous feedback*. Human-computer interaction–INTERACT 2011 (pp. 627–642). Berlin: Springer.

Borrego, M., Douglas, E., & Amelink, C. (2009). Quantitative, qualitative, and mixed research methods in engineering education. *Journal of Engineering Education, 98*(1), 53–66.

Bussières, J.-F., Métras, M.-É., & Leclerc, G. (2012). Use of Moodle, ExamSoft, and Twitter in a first-year pharmacy course. *American Journal of Pharmaceutical Education, 76*(5), 1–3.

Camiel, L. D., Goldman-Levine, J. D., Kostka-Rokosz, M. D., & McCloskey, W. W. (2014). Twitter as an in-class backchannel tool in a large required pharmacy course. *American Journal of Pharmaceutical Education, 78*(3), 67.

Case, J. M., & Light, G. (2014). Framing qualitative methods in engineering education research: established and emerging methodologies. In A. Johri, & B. Olds (Eds.), *Cambridge handbook of engineering education research* (pp. 535–550).

Du, H., Rosson, M. B., & Carroll, J. M. (2012). Communication patterns for a classroom public digital backchannel. In *Paper presented at the proceedings of the 30th ACM International Conference on Design of Communication*.

Fox, B., & Varadarajan, R. (2011). Technology in pharmacy education: use of Twitter to encourage interaction in a multi-campus pharmacy management course. *American Journal of Pharmaceutical Education, 75*(5), 1–9.

Fried, C. B. (2008). In-class laptop use and its effects on student learning. *Computers & Education, 50*(3), 906–914.

Gehlen-Baum, V., Pohl, A., & Bry, F. (2011). Assessing Backstage—A backchannel for collaborative learning in large classes. In *Paper presented at the 14th International Conference on Interactive Collaborative Learning (ICL)*.

Holzer, A., Govaerts, S., Ondrus, J., Vozniuk, A., Rigaud, D., Garbinato, B., et al. (2013). *Speakup–a mobile app facilitating audience interaction*. Advances in Web-Based Learning–ICWL 2013 (pp. 11–20). Dordrecht: Springer.

Junco, R. (2012). In-class multitasking and academic performance. *Computers in Human Behavior, 28*, 2236–2243.

Kraushaar, J. M., & Novak, D. C. (2010). Examining the affects of student multitasking with laptops during the lecture. *Journal of Information Systems Education, 21*(2), 241–251.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Lin, M.-F., Hoffman, E., & Borengasser, C. (2013). Is social media too social for class? A case study of Twitter use. *TechTrends, 57*(2), 39–45.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage.

National Post. (2015). *Professors declaring classrooms laptop-free zones*. Retrieved from http://www.nationalpost.com/news/story.html?id=18a506fe-13c1-40dd-87c9-49d46100bdcb&k=21800.

Pohl, A., Gehlen-Baum, V., & Bry, F. (2012). Enhancing the digital backchannel backstage on the basis of a formative user study. *International Journal of Emerging Technologies in Learning (iJET), 7*(1). Retrieved from http://www.editlib.org.ezproxy.uct.ac.za/p/44889/.

Ragan, E. D., Jennings, S. R., Massey, J. D., & Doolittle, P. E. (2014). Unregulated use of laptops over time in large lecture classes. *Computers & Education, 78*, 78–86.

Ratto, M., Shapiro, R. B., Truong, T. M., & Griswold, W. G. (2003). *The ActiveClass project: Experiments in encouraging classroom participation*. Designing for Change in Networked Learning Environments (pp. 477–486). Dordrecht: Springer.

Rockmore, D. (2014). The case for banning laptops in the classroom. *The New Yorker*. Retrieved from http://www.newyorker.com/tech/elements/the-case-for-banning-laptops-in-the-classroom.

Strauss, A. L. (1987). *Qualitative analysis for social scientists*. Cambridge: Cambridge University Press.

Welch, B. K., & Bonnan-White, J. (2012). Twittering to increase student engagement in the university classroom. *Knowledge Management & E-Learning: An International Journal (KM&EL), 4*(3), 325–345.

Wilson, V. (1997). Focus groups: a useful qualitative method for educational research? *British Educational Research Journal, 23*(2), 209–225.

Yates, K., Birks, M., Woods, C., & Hitchins, M. (2015). #Learning: the use of back channel technology in multi-campus nursing education. *Nurse Education Today, 35*(9), e65–e69. Retrieved from http://www.sciencedirect.com/science/article/pii/S0260691715002658.