IMMEDIATE FEEDBACK: A NEW MECHANISM FORREAL-TIMEFEEDBACK ON CLASSROOM TEACHING PRACTICE

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ABSTRACT

The proliferation of technology has re-defined the traditional learning environment. The classical classroom model of teacher to student delivery is changing as technology becomes more pervasive in educational environments. In addition, the availability of technology and the breadth of different device categories and platforms is a stark contrast to the traditional classroom, and the pervasiveness of low-cost devices provides opportunities to significantly re-define the learning environment. In this paper, we have developed a real-time feedback mechanism supported by technology to allow students and educators to assess comprehension in the teaching environment. Real-time feedback is input that is acquired whilst a teaching practice is ongoing, and the outcomes derived from the feedback mechanism have provided a strong pedagogical value to the learning environment. These benefits have been clearly elicited by the academic staff who trialled the system.

KEYWORD

Immediate feedback, real-time feedback, response system, clickers, synchronise feedback

INTRODUCTION

It is important for educational researchers to understand how real-time feedback mechanisms can benefit student learning and the circumstances in which different categories of technology can be applied, and in-depth studies by researchers contribute to making education more accessible to more people by using technology. This encourages students and teachers to adopt the use of educational technology on the one hand, and on the other hand, encourages innovators and developers to create technologies and solutions for educational environments. However, there is a reluctance of students to ask for help to understand lecture material and an inability of educators to gauge effectively class comprehension when large cohorts of students are involved. In this paper we determine the reasons for these obstacles and propose a new approach to overcome this problem which centres on the interface between the student and the educator providing real-time feedback to the educator without requiring any specialist equipment or room configurations.

Our definition of feedback can be stated as information regarding a current teaching practice that can be used to influence or alter subsequent or current practices. This may include a response from a colleague in the classroom, comments or corrections carried out by the educator, or feedback from the students to the educator regarding the cognition of teaching materials and practices. Feedback is not only important for the student, it is also of great importance to the educator and is a real measure of the quality and effectiveness of teaching delivery.

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BACKGROUND

Technological approaches to obtaining class feedback have employed many forms of devices and interaction styles, and we summarise here both the technologies used and the benefits to educators and students.

Augmentedrealityisamoderntechnologyusedinnextgenerationclassrooms.The term ‘augmented reality’ (AR) refers to the possibility of merging information with the real world by adding a range of useful overlays to the visual perception of the human. A study by Zarraonandia et al. [1] which used this technology in the classroom to obtain continuous feedback from student to teacher employed a system composed of many components. Students used their mobile devices to interact with the system to provide feedback, and the lecturer wears AR Google glasses to see which student understands the concept by the interacting through Microsoft Kinect. The feedback system processes information and represents it on the AR device. This research added a new way to allow bi-directional communication in real-time between teacher and student to identify students who grasp or fail to grasp concepts. The feedback system using AR helps to overcome the problem of student reluctance when asking questions in front of their colleagues, and the students agreed on the improved communication and engagement with the educators.

However, the system reported in [1]had many limitations which our new approach, and the system we have developed to implement it, address. The core features of an AR system include the educator being able to individually identify which student is understanding the material and vice versa. Anonymous feedback is preferred by students, as the goal of feedback is to improve the explanation of a concept, and this was a concern highlighted in past research[2],[3]. The system we have developed does not suffer from this identity problem as no feedback is personally identifiable. Importantly, our system makes this clear to students in a logical and consistent user interface which transparently shows how the data are collected. This helps to make the students feel comfortable when providing feedback as their aggregated input is displayed in a de-identified manner (on a projector). Moreover, the AR technology is not suitable for crowded classrooms. Our system is completely scalable, from 1 audience member to 1000, onsite or offsite, and the use of extensible web frameworks is a significant benefit. Furthermore, wearing glasses is inconvenient for the teachers, since it may cause undesirable effects on the eyes in the long run. The system we have developed uses existing technology and it is very familiar to both the educator and student. This familiarity has benefits over previous AR systems in terms of cost and training, as we have kept this to an absolute minimum.

Clickers are another technology enabling the lecturer to get feedback during lectures. This technology works by using radio frequency as the clicker devices ends signals to a receiver in the room and a computer processes information for presentation. Through this technology, the teacher can ask a question and within a few seconds student responses appear on a computer without revealing their identities. The device works through a special program to register students’ answers, enabling the teacher to assess whether the students understand the concepts during the presentation. For example, the teacher can ask questions «true or false» or multiple answer questions to everyone, and within a few seconds the system records answers from the students and the results are presented. Thus, during the lecture, the teacher can decide if students need immediate help.The teacher obtains students grades within a few seconds, instead of taking papers to grade.

Caldwell [4] reports the use of clicker technology to investigate student perspectives, and the results showed 36.2% of students approve of the technology as it gave them feedback about the understanding of materials. 22.9% of students reported that using this technology made a lecture interactive rather than the traditional class. However, the findings of this research showed that many students faced connection problems with the clickers. When the researchers asked students why they dislike this technology, they reported because of time wastage, technical reasons and poor usage in class. However, overall clickers have been reported to be highly effective in large classes both in terms of the teacher or the student outcomes. As this technology was derived more than 50years ago, the emergence of newer technologies such smartphones may make clickers redundant. In addition to environment requirements and booking devices before the lecture, the cost may make using this technology prohibitive. Our approach has some similarities with the clicker technologies, but addresses its shortcomings in a comprehensive manner. Firstly, custom RF technology is not used, instead were lyonWi-Fi, a much more standardised approach with greater reliability. In addition, the support for any form of browser-enabled device allows for selecting devices without bias and is not locked into proprietary technology, hence reducing cost. Lastly, the system can be understood as a passive data collection and display technology, the lecturer does not have to stop and ask for feedback, therefore is much easier to integrate into any classroom compared with disruptive clicker technology.

Poll everywhere technology provides effective real-time feedback in crowded theatres[5]. Unlike clicker technology, Poll everywhere does not require any special equipment to participate, it only requires mobile or tablet devices. The questions for the poll are prepared before the lecture by the lecturer, and students in the lecture will answer these questions under lecturer guidance. Using this technology, students get assessment feedback and know which answers are correct or incorrect immediately. In addition, it makes lectures more interactive, and students can discuss and debate during the lecture session, encouraging all students to participate rather than enthusiastic students who sit in the front row. Moreover, lecturers can ask students if the explanation of a concept is clear. Using Poll everywhere, lecturers can examine student understanding and try to change their delivery style for the concept to be clarified. A research study was conducted on 130 students in a criminal law subject using the Poll everywhere system, where 100% of students bring their mobile phones to university and 79 students responded using this technology [5], about 43% said "it showed them points they had understood and misunderstood". However, some students preferred clickers rather than Poll everywhere because they found clickers quicker and easier to use.

E-Slide Feedback Mechanism

Creating a new proposed feedback mechanism using resources that exist in any classroom is the aim of this research. Unlike other mechanisms which require special devices or disruptive questioning, this mechanism utilises the personal technology of students and the class computer. The use of slideshows in educational environments is a common method to present information which is effective for large audiences where the communication type is one (presenter) to many (audience).Through the literary survey, several existing technologies have been presented that partially seek to improve this situation. However it is clear that the creation of new technology solutions is required, motivated by the need to incorporate available resources in the learning environment without having to deploy specialised devices. Therefore, we propose to addresses these issues through a system we term 'E-slide Feedback System'. We seek to use electronic slideshows and feedback mechanisms using commonly available technology as a basis for the system.These are pervasive in the teaching environment and support communication of most forms of information such as text, image, sound and video.

METHOD

System Functions

The system works in the following way. Students would select the subject and lecture from a list in the via a web app. As the lecture progresses, the student uses the app on their internet con nected device to indicate that they are understanding or not comprehending the content. The app UI in this instance is as simple as having two large touch sensitive boxes, red and green. The data are collected by the server and the results are processed in real-time. The output is presented on the lecturer's presentation machine, or possibly their own mobile device, as they are delivering the lecture, and is further captured on the server together with the details of the interaction in the lecture to which the output relates. The lecturer is therefore getting real-time feedback as to how their teaching is being understood by the students, and students can see the feedback if the slideshow is being projected. If necessary, the educator could explain further or change their style as they will get instant feedback via this system. At the end of the lecture, the lecturer could retrieve the whole dataset(statistics captured per presentation slide) and seek to make improvements of their lecture, e.g. try again with updated techniques or material next semester and compare the results.

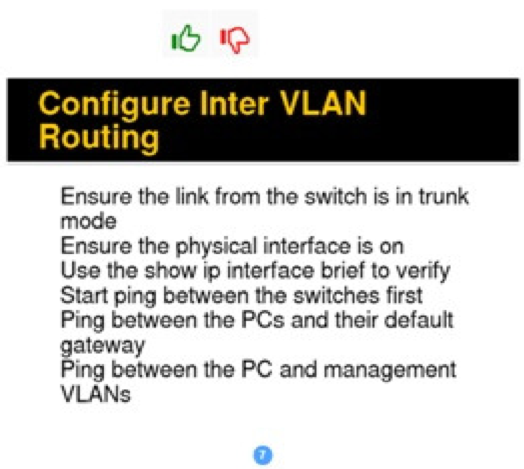

Figure 1: User interface for students

Figure 1 shows the user interface for students via their devices. It contains the lecture slide and two icons above, students tap the green icon if they understand the content or tap on the red box if they are unclear. These two icons appear to the students in two ways: per slide or per group of slides (as a concept). The lecturer will set up these two structures in a lightweight process before lecture time using the system. This interface prioritises simplicity in order to allow the student to focus on their learning, with distraction.

Figure 2 shows how the results are displayed on the presenter's screen during the lecture. The results are displayed for each slide or group of slides in real time in the form of a gauge. It is presented in 'slide order' to make it easier for the lecturer to know the response relating to each slide. This is an effective manner to allow the presented to obtain feedback in real-time and further clarifications during lecture if required. This is efficient for teaching as concepts won't have to be repeated later, or if the lecture is archived offline.

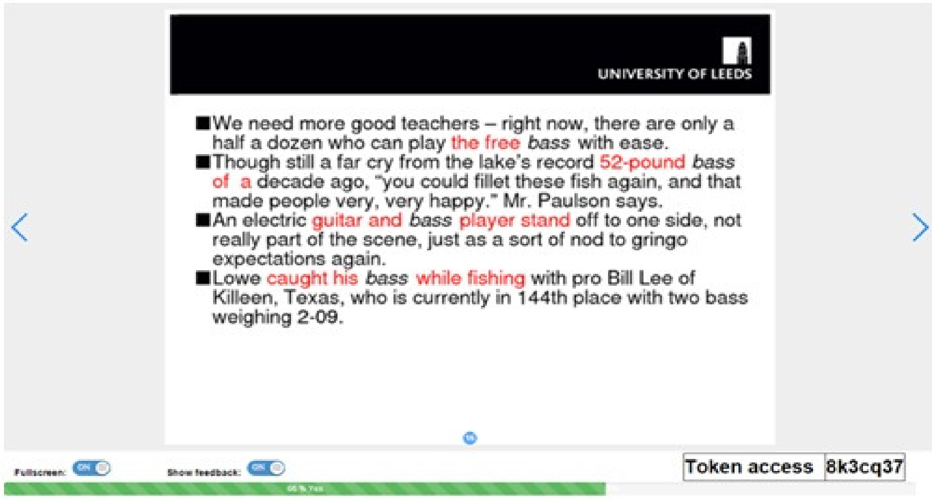

Figure 2: Lecture interface in real-time mode

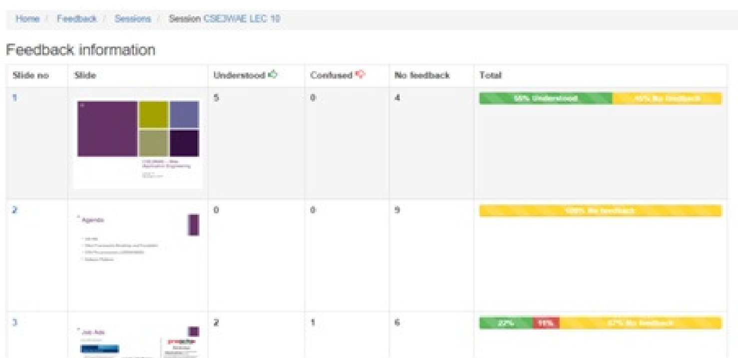

Figure 3: statistics for the proportion of students' understanding

Figure 3 illustrates how statistics are presented for the proportion of students understanding content by slide (or by agroup of slides which presents a certain concept). It helps the educatorto identify which aspects or concepts the students found difficult, and may thus serve as a platform for improving subject materials.

Participants:

The survey population was taken from undergraduate {CSE3WAE, CSE3PE, CSE3MQR, CSE3ANE, CSE3DES} or graduate level {CSE5ITP, CSE5ANE, CSE5MQR, CSE5ANE, CSE5DES} lectures in teaching weeks 9-11 in semester 2, 2015 at La Trobe University, Melbourne, Australia. In total 11 lecturers and 112 students participated in the study. The choice of subject was decided based on the criterion of having large student enrolments as a critical sample size was required to investigate the education outcomes from the system. The actual number of student respondents per subject is shown in Table 1.

Table 1: Student responders per subject

Subject	Number of Student Respondents
CSE3WAE	9
CSE5ITP	14
CSE3MQR + CSE5MQR	18
CSE3DES+CSE5DES	28
CSE3ANE+CSE5ANE	26
CSE3PE+CSE5PE	17
Total	**112**

Table 2: Questionnaire details

Student - perception survey items	
RQ1	**Does the E- slide feedback technology support teaching methodologies through student engagement? (Student Engagement)**
1	Using E-slide Feedback encouraged me to attend the class.
2	I felt the lecture experience was improved using ‘E-slide Feedback’.
3	I am comfortable raising questions during a lecture regardless of using technology.
4	I am comfortable providing feedback using ‘E-slide Feedback’.
RQ2	**Does the E- slide feedback technology support cognition of lecture material?(Student Learning)**
1	The use of ‘E-slide Feedback’ improves my understanding of the lecture content
2	The use of ‘E-slide Feedback’ helped me to send feedback about my understanding.
3	The use of ‘E-slide Feedback’ did not disrupt my learning.
Lecturer- perception survey items	
RQ3	**Does the E- slide feedback technology support cognition of lecture material?(Pedagogical value)**
1	The use of ‘E-slide Feedback’ helped me to monitor student understanding.
2	The use of ‘E-slide Feedback’ helped me to modify my delivery of the subject material if the class was indicating confusion.
3	The captured results from ‘E-slide Feedback’ will help me to improve the course content in future semesters.
4	E-slide Feedback promoted active learning.
5	E-slide Feedback was easy to use and I will consider integrating it into my subject in the future.

A student-perception questionnaire (Table 2) included 7 quantitative items related to engagement and learning factors. A lecturer-perception questionnaire included 5 quantitative items related to pedagogical value. Both questionnaires employed a five-point Likert-type scale which displayed results in the range 1 (strongly disagree) to 5 (strongly agree). To ensure valid results, the survey development process included a systematic review of related literature, and the conceptual framework of the both questionnaires were based on Weston and Cranton's (1986) instructional strategy approach in higher education [6]. This framework involves defining the interaction between student and teacher, the 'teaching method' and secondly 'materials' as resources distributed to students to assist in their learning. The questions thus focus on perception around teaching methodologies and the quality of teaching materials.

Data Collection Procedure

Lecturers were asked to voluntarily participate in the study, and due to the timing of data collection (late in semester 2, 2015), subjects with larger enrollments were selected. Once approached, an announcement was either given by the lecturer, or announced in the preceding lecture informing students that their participation would be requested in the next lecture. A user guide was distributed to the lecturer to train them on using the system. A major design goal was to enable rapid uptake through intuitive design, and training and demonstration to new users were completed within 5 minutes.

Figure 4: Students in a lab session using E-slide Feedback technology

During the initial 2 minutes of each lecture, an announcement was made to students to enter the system via a browser on their mobile device using the on-screen token code. The lecture would then commence as students participated along with the lecturer. The system in action can be seen in figures 5-6.

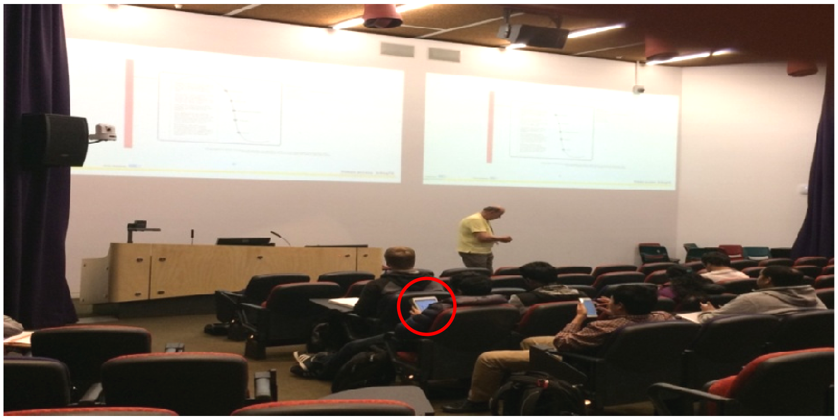

Figure 5: Students in lecture session using E-slide Feedback technology by their personal technology

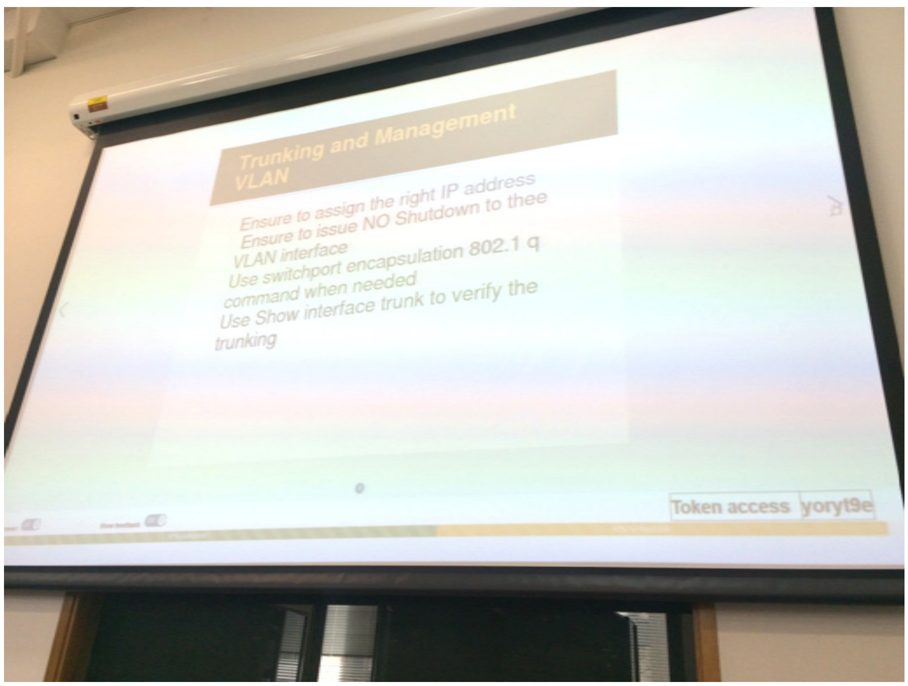

Figure 6: Real-time feedback progress bar of E-slide Feedback technology

The user interface visible to both student and lecturers is shown in Figure 6.

In the last 5 minutes of the lecture, both lecturer and students were invited to fill the paper-based questionnaire and return it for collection to the designated box at the front of the lecture room.

Data analysis

Data analysis was conducted using SPSS, and included: (1) descriptive statistics, used to investigate student perceptions of using E-slide Feedback technology in terms of student engagement and learning;(2) descriptive statistics, used to determine lecturer perceptions of using E-slide Feedback technology in terms of pedagogicalvalue. All three categories (student learning, student engagement and pedagogicalvalue) used response variables to calculate mean and standard deviation.

FINDINGS AND DISCUSSION

The first stage in result presentation was to gauge the level of reliability of the Likert question set. As each question had 5 options as described previously, the Cronbach's alpha test was executed to demonstrate the measure of the latent variable related to the grouped educational research question. The scale consisted of student perception (called student engagement and learning) and lecturer (pedagogical outcomes) items. Both were found to be reliable (α = .959 for the student questionnaire and α =. 807 for the lecturer questionnaire).

6.1 Student Engagement

The next set of results to present are those surrounding each question on the questionnaire. We first show the questions related to student engagement. Here the 5 points Likert scale is compressed into 3 for clarity.

Table 3: Impact on student engagement (student perceptions)

Item	Student Engagement items	Strongly Disagree OR Disagree	Neither Agree/Disagree	Strongly Agree OR Agree	Mean	Std. Deviation
1	Using 'E-slide Feedback' made me more attentive to the lecture	10.7%	19.6%	69.6%	4.2857	1.11847
2	Using E-slide Feedback encouraged me to attend to the class	17.9%	33.0%	49.1%	3.8036	1.22907
3	I felt the lecture experience was improved using 'E-slide Feedback'	21.4%	19.6%	58.9%	3.9643	1.28700
4	I am comfortable raising questions during a lecture regardless of using technology	4.5%	22.3%	73.2%	4.4196	.98309
5	I am comfortable providing feedback using 'E-slide Feedback'	13.4%	16.1%	70.5%	4.2768	1.15634

As shown in Table 3, overall the feedback indicated a strong response to the 'agree' end of the range, with all of the mean response values tending toward Strongly Agree (more favourable in this case – a value of 5.0 corresponds to "Strongly Agree OR Agree"). With the exception of question 2, over 50% of the responses for each question were "strongly agree" or "agree". These values are represented in table 3. The highest value (mean = 4.4196) was for Item 4 –I am comfortable raising questions during a lecture regardless of using technology. The second highest value occurred for the first and last item (4.2857 and 4.2768 respectively). Items 3 and 4 were similar with M=3.8036 and M= 3.9643.

Student engagement

One of the goals of the project was to develop a comprehensive outcome that will help students engage in their learning. The system provides an easily accessible technological solution that puts the student in an active role to interact with the classroom delivery of content. Using technology in this manner provides an advancement to a classical educational delivery practicethat has not changed with the pace of technological innovation.

Improving student attentiveness

Student response showed a mean value of 4.3 indicating a strong perception that the system made them more attentive to the lecture content. One of the key educational motivations was to use technology to help students focus on their content, not shift their focus elsewhere. The user interface showing a mirroring of the lecturer console synchronised in real-time and placed on the students' devices made them very aware of the progress of the lecture. The system essentially brings attention to the lecture material by displaying real-time statistics on the theatre projector and also placing a copy of the presentation in the hands of the students.

This result was consistent with a study similar to E-slide Feedback technology but with clickers technology [7],which suggested that students can effectively multi-task, i.e. provide feedback while they are learning concepts delivered by the educator.

Figure 7: Mirroring of the lecturer's console synchronised in real-time

Encouragement to attend class

Student responses showed a mean value of 3.8, and as the lowest of this question set, the implications of this are of interest. Firstly, a score of 3.8 is a solid 'agree' range outcome but themotivation to attend is a theme that many educators grapple with [8]. Perhaps the lecture material is not best suited for delivery in the current format or student motivation is being lowered by factors outside of the reference of this study. Further research is required on this association between attendance and motivation. Motivated students attend lectures with or without external factors such as additional technology support, however it is the population of students who are of wavering commitment that we seek to convert and to target.

Improvement in lecture experience

The student mean feedback score was 3.96 again strongly in the ‘agree’ range. The marker of success for improving the lecture experience is the perception that the student takes away from their lecture. Has the system added benefit? This may be viewed in terms of how the lecturer was able to modify and incorporate the technology into their delivery to maximise the educational appeal. As all the lecturers were trialling the system for the first time, they may have required some practice at becoming more proficient at real-time responsiveness to student demands. A follow-up from this trial would be to survey students after their educator had two or more semesters experience with the technology.

Student comfort in raising questions regardless of technology

This outcome was of particular interest with a mean score of 4.4. One of the outcomes from prior research indicated that students felt uncomfortable raising their questions in front of an audience and stopping the educator [9]. The student responses would indicate otherwise. When viewed in the context of this study, the results however did make sense. Since this study surveyed students at the end of a semester, and in general sampled only a small percentage of the overall students enrolled we could see a bias in the sample population. Late in the semester, the most motivated students tend to make time to still attend lectures, instead of using the time to catch-up on other assignments or external matters. It would therefore make sense that out of the total student cohort, those who would most likely feel comfortable raising questions in class would be the most motivated students, perhaps explaining our results.

Comfort in providing feedback using the system

A key success factor for an educational system is the willingness of students to keep engaging. Student mean scores were 4.27, in the agree/strong agree range. The form of the real-time anonymous feedback we suggest thus provided a level of comfort for students to engage with the educator. This suggests that providing students with immediate feedback is very desirable as it promotes engagement and the students see their contributions are making a difference. Thus ease of use and validation in the mind of the participant promotes comfort and willingness to use the system, as has been identified in another study using ‘clicker’ technology [10].

Student learning

Understanding how students learn and how content can be delivered to promote learning is a complex issue and one that our system can help to assist with. The analysis of student responses from their learning activities using the system are presented in the following subsections.

Improving understanding of lecture content

The student mean response was 3.89, in the agree/strongly agree range of results. From a student perspective an improvement in understanding could be considered as cognition of a concept or being more agreeable to the delivery style of the educator. This aspect of our system relies upon the lecturer where we are the enabler for the improvement process. As the lecturers who trialled the system did so for the first time, it might have been beneficial if they had had more experience, however this is a limitation of the study. The use of real-time feedback is a shift in classical teaching delivery, thus some degree of experience from the educators would be likely to enhance outcomes from the student perspective.

Helping to send feedback

The student mean response was 4.49, a very strong statement about the usefulness of the system. The user interface, together with the choice of technologies on the client and server-side, are critical to a positive user experience. For the student to be able to communicate and see their feedback and have that shown in the context of their peer's experiences, closes the feedback loop and promotes engagement.

E-slide technology is very simple for both student and educator to use, and the user interface has been designed to allow instant communication using the clearest interaction paradigms in two steps (Figures 8-9).

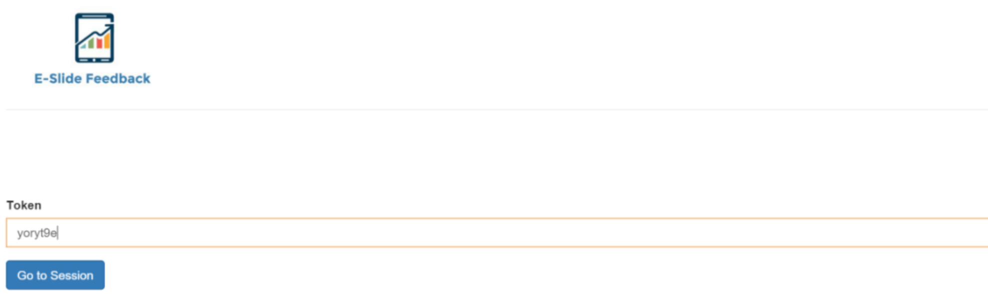

Figure 8: Step 1 – Students login via token access to make the system very easy to use

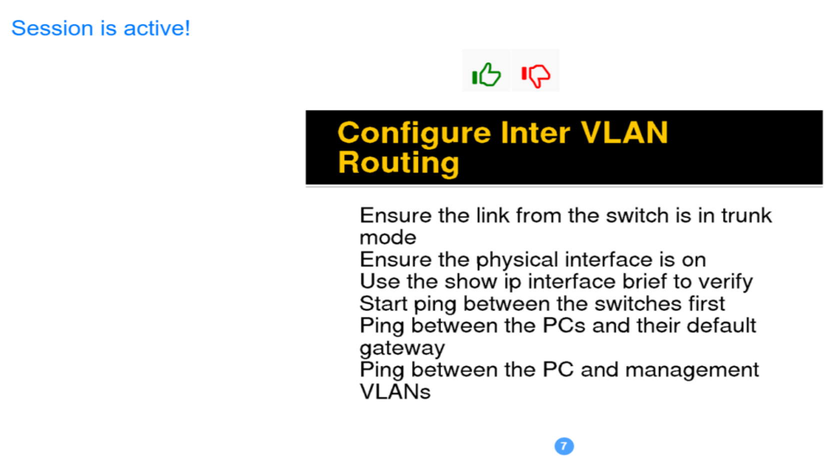

Figure 9: Step 2 – Students send feedback of the thumbs up and down

The student view, as shown in Figure 9, provides a very simply and understandable feedback mechanism. It is language independent, and is very familiar to the general population as these icons and colour schemes are universally used in iconography and web systems.

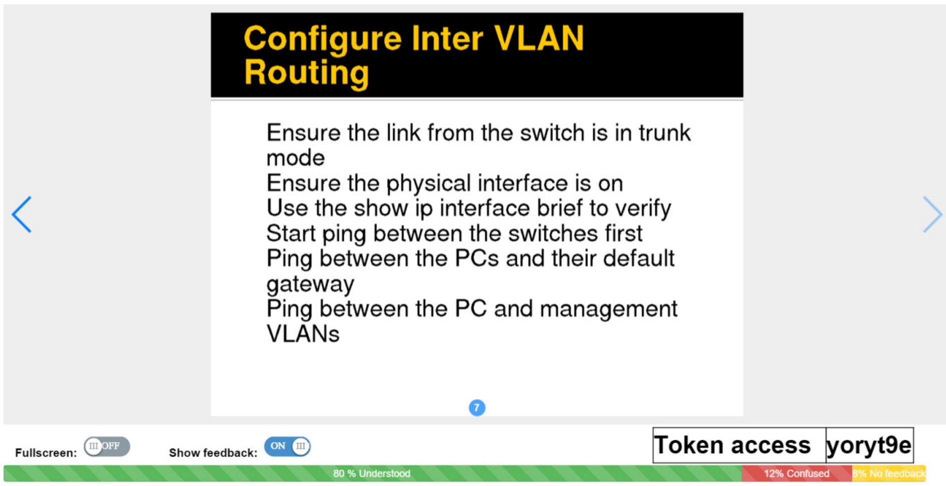

Figure 10: Lecture screen showing the real-time feedback progress bar

The class's view of the system on the projector as shown in Figure 10 again incorporates familiar visual design elements. The use of a summary bar is well known to the general internet using population and the colour coding shows positive, negative and uncommitted distributions clearly.

Non-disruption of individual student learning

In this aspect, students scored the system 4.09, agreeing with the statement to a strong level.To be relevant as an educational technology, the system must not distract or detract from the way a student focuses on the material. Students using their own devices promotes familiarity and integrates into their existing educational practice. The design of the user interface does not require a high cognitive load as the paradigm is one already familiar to many people.

Non-disruption of the teaching environment

In this aspect, students scored the system 4.08.This is another clear indicator that the system is of strong educational value. The system supports rapid deployment into existing teaching environments and does not interrupt the delivery of material.

Pedagogical contribution

The system when used by the educator is analysed in the following subsection with an emphasis on whether a clear pedagogical benefit can be obtained.

Monitoring of student learning

The lecturer's mean feedback score was 4.6, thus indicating strong support for this outcome. The real-time aspect combined with the quick and easy comprehension of results is an important feature of the system.

Real-time modification of delivery

The lecturer's mean feedback score was 4.6 – with alittle introduction to using the system, lecturers overwhelmingly suggested they were able to adapt their teaching style based on the level of understanding from the student cohort. This is a priority goal of the system and shows lecturers are flexible and responsive to student needs. The outcome indicates a high level of student satisfaction and lecturer motivation.

Future materials improvement

The lecturer's mean feedback score was 4.8, thus indicating strong support for this outcome. Toward capturing and renewing material, the system also records student voting patterns per slide for offline analysis by the educator, perhaps with the view to improving the material or teaching style in the future or toward understanding what concepts students find difficult.

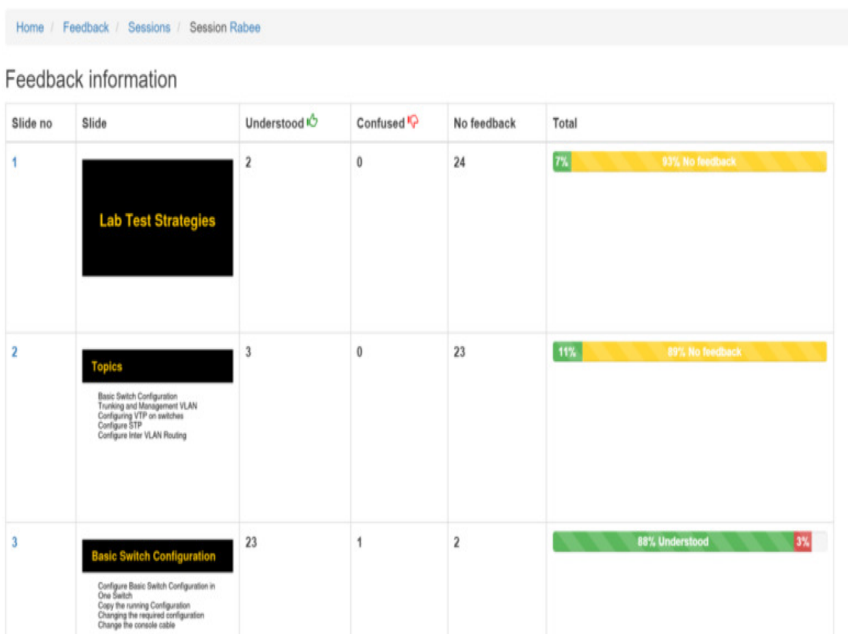

Figure 11: The feedback recorded for later analysis

Figure 11 shows the results that were recorded for a particular lecture. This easy to understand output helped the system gain a high score with the lecturers who evaluated the system.

Promoting active learning

The lecturer's mean feedback score was 4.4, thus indicating strong support for this outcome.The system had the effect of engaging students with the lectureby requiring them to provide feedback. As the shape of the lecture could change based on real-time feedback, the evaluating academics strongly supported the statement regarding active learning by students. Active learning has been defined by Bonwell and Eison [11] to incorporate the following aspects, and Table 4 presents these and our contributions to active learning.

Table 4: Bonwell and Eison characteristics with E-slide Feedback mechanism contributions

Criteria [11]	E-slide Feedback Contributions
Students are involved in more than passive listening	Students have to listen, understand and evaluate their understanding of concepts
Students are engaged in activities	Students have to engage by providing feedback and seeing their class summary in real-time
There is less emphasis placed on information transmission and greater emphasis placed on developing skills	The system can assist in giving advice for later revision
There is greater emphasis placed on the exploration of attitudes and values	The system allows the educator to better understand how students learn
Students can receive immediate feedback from their instructor	This is true of E-slide Feedback where it provides the educator the ability to give real-time modifications to their teaching
Student motivation is increased	The system provides an incentive to come and participate in lectures
Students are involved in higher order thinking	The system requires students to evaluate their thought process and how they study

Uptake in future lectures

The lecturer's mean feedback score was 4.8, and the marker of success and the strongest response in this study was the willingness for academic staff to continue using the system into the future. This endorses the learning objectives from both the student and educator perspectives.

CONCLUSIONS

The E-slide Feedback technology system provides strong pedagogical value to the learning environment by connecting all participants in real-time. This was clearly demonstrated from the academic staff and students who trailed the system. The E-slide Feedback system allowed participants to engage and feedback their experiences during university lectures. This was determined through observation of real usage and through questionnaires. The E-slide Feedback system contributes strong outcomes for students where they are central and engaged in the learning process.The solution is scalable, a very important factor where thepersonal connection is lost in crowded teaching environments. The system had improved the student learning experience and has been strongly acknowledged to provide pedagogical value.

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