A Novel Real-Time Detailed Feedback Collection and Interaction Tool for Large Classes

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CONTEXT
The existing approaches towards interactive student feedback and question collection have two major drawbacks. First, instructors are only provided with generic feedback, typically at the end of a teaching period. Second, students are not provided with opportunity to give content-specific feedback or raise questions on specific sections of content during the lecture. The latter is especially important in large classes with students from non-English speaking background who are generally less likely to actively participate in discussions.

PURPOSE
This paper aims to develop and test a user-friendly and automated platform, with efficient data management structure, which facilitates real-time collection and addressing of students' feedback on a specific part of topics discussed during the class.

APPROACH
A web-based software has been developed using annotation technologies which assists students in providing anonymous and content-specific comments on lecture materials. The software equips lecturers with a real-time platform for retrieval of comments classified based on their area, type and frequency. The platform contains features that enable users, teachers, for analytical assessment of both teaching and learning performance.

RESULTS
The trial use of the designed platform has primarily increased engagement of students in the class discussions. This trend is specifically observed amongst international students who have gained confidence to raise more questions, compared to the traditional teaching methods. Concurrently, the lecturer has dramatically decreased his response period to students' queries to nearly real-time through receiving classified comments adhered to a particular part of the lecture.

CONCLUSIONS
The software allows for structured analysis of course materials and students' feedback which can be further used to update teaching standards. Moreover, it improves teacher-student relationships through timely and purposeful addressing of instructional issues.

KEYWORDS
Real-time feedback, Interactive teaching and learning, e-Learning.

Introduction

The relevant literature prioritizes interactive teaching over passive teaching due to its effectiveness in improving students' learning performance (Datta et al., 2015, Felder and Silverman, 1988, Johnson et al., 1998, Prince, 2004, Wankat and Oreovicz, 1993). To the advocacy of interactive style, students are central and hence, all aspects of teaching and learning are shaped to satisfy educational needs of students with different capabilities (Lau, 2003, Milton and Lyons, 2003, Nguyen et al., 2012). A fundamental step towards interactive methods of education is taken at the time of curricula development and course design (Lam et al., 2016). The course content is designed to ensure that adequate interactions between instructors and students take place during in-class hours (Chang et al., 2006, Datta et al., 2015). These interactions are primarily triggered through the lecture in which a mixture of materials representing different instructional strategies is assembled (Johnson et al., 1998, Lam et al., 2016, Meyer, 2003).

The course design has become a dynamic and on-going process (Welch et al., 2005). To maintain the students' learning needs, higher education institutions constantly examine the quality, effectiveness, and efficiency of their teaching methods (Boyer, 1990). A common approach is to survey student satisfaction and opinions about a course, its content, and teaching performance (Van den Hurk et al., 2016). Such surveys have two major drawbacks. First, they are typically conducted at the end of a teaching period and analytical feedback is made available to an instructor afterwards. Hence, the earliest possible time at which the lecturers can accommodate the received feedback into course design and teaching strategy is the subsequent teaching sessions when new students, with possibly new learning needs, take the course. Second, the surveys are designed to collect data on overall quality of the course during the whole teaching period. This allows students to make overall assessments by providing broad feedback. In addition to the format of the survey, its time-lapse, with respect to teaching period, doesn't inspire respondents to make content-specific comments.

Technology has shown its potential in facilitating design and delivery of interactive pedagogy (Walker and Johnson, 2008). By the advent of the growing number of online tools, academic institutions have envisioned to improve learning performance through enhancing students' engagement (Schmidt, 2002, Sharma and Barrett, 2007, Soh and Gupta, 2000). Moreover, application of technology has become prevalent in feedback collection over the courses taught (Datta et al., 2015, Kamarainen et al., 2013, Van den Hurk et al., 2014). Nonetheless, technology has not achieved its full potential in real time interactions between instructors and students during the lecture. Technology can be particularly coupled with delivery of course materials in large classes with 100+ students where there is a mixture of native and non-native English speakers from different backgrounds. In the absence of technology, the in-class classical questioning and answering interactions have two major drawbacks. First, by considering the limited duration of lectures, it is only practical to allow a limited number of questions and discussions during the lecture, especially given the fact that questions tend usually to raise new follow-up question and discussions. Second, students from non-native speaking backgrounds or people with low self-confidence may be reluctant to make their points due to psychological reasons. These can diminish effectiveness of planned interactive teaching methods through reduced participation in class discussions.

To address the above issues, this study aims to develop and test a user-friendly platform which facilitates real-time collection and addressing of students' feedback on a specific part of course materials. Accordingly, a web-based software is developed using annotation technologies which enables students in providing content-specific comments on lecture materials. The software enables lecturers retrieve classified feedback and comments in real-time. The comment classifications include associated knowledge area, type, and frequency. Through features embedded in the software, the lecturer can opt to address the comments in a written response to an individual student, to the whole class, or verbally during the lecture. In addition, this tool contains features that enable users in assessing quality of teaching and learning through detailed analysis of lectures and comments. Application of this tool has been tested in four lectures of a course at School of Civil and Environmental Engineering in University of New South Wales (UNSW).

Background

A fundamental element contributing to scholarly teaching is related to the readiness of students (Boyer, 1990). The readiness of students is characterized by their learning abilities which are commonly interpreted through their learning styles (Drnevich, 2001). The characterisation process is usually fed by feedback and input from students which can be collected under formal and informal modes (Felder, 1993, Wankat and Oreovicz, 1993). Formal mode of feedback collection is commonly managed independent of the lecture at the end of a teaching period (Wankat and Oreovicz, 1993). Informal feedback can be assembled throughout a lecture using different techniques (Johnson et al., 1998). Analysis of formal feedback is thoroughly performed by the schools to understand compatibility of the lectures with students learning needs. This process is, however, passive and its results, at best, can be accommodated into course design of next academic year. In addition, the analyses are quiet generic on the overall quality of a course (Van den Hurk et al., 2016). In contrast with formal systems, informal feedback is usually gathered multiple times during a lecture through employing different instructional strategies, such as in-class activities and homework (Blumenfeld et al., 1991, Cole, 2009, Soh and Gupta, 2000). In this approach, analytical assessment of students' performance is currently neither systematic nor peer-reviewable and therefore, its benefits to improvement of course materials are limited.

In line with the students' learning styles, instructors should develop a teaching method that best conform to the results of formal or informal feedback (Vian, 2007). They may take a blend of instructional strategies when designing course content. The relevant literature suggests various forms of instructional strategies which have been classified into five groups; traditional, activity-based, relational, web-enhanced, and student-centred methods (Lam et al., 2016). The effectiveness of traditional teaching and student/lecture interaction strategies, viz. lecture, tutorial, and case method teaching, have been widely assessed by previous studies and highlighted as inadequate for effective acquisition of intended skills among students (Vian, 2007). To address this, it has been suggested to incorporate approaches that provide students with a hands-on experience on the taught materials such as real or virtual field trips (Akdemir and Koszalka, 2008). In-class role-plays and television game shows designed by instructors are classified as activity-based teaching and are intended to improve engagement of students (Blumenfeld et al., 1991). However, there are scepticisms about the effectiveness of such activities mainly due to their likely distracting impact and time management challenges particularly in large classes. To improve engagement of students, it is required to establish more than one motivator in the course design (Nelson et al., 2015). To establish a parallel motivator, inviting guest speakers and using popular videos related to course content are highlighted as "relational" strategies and used widely to consolidate students' understanding of course concepts (Mayer, 2003). In order for an instructor to dynamically design an effective mixture of these strategies, however, a systemic framework is required to constantly collect students' feedback on each piece of the taught course.

Online technologies have been popular in education and are integrated with traditional methods to improve course delivery experience. These technologies have been mainly used to assist students with their out-of-class activities and assignments related to a course (Schmidt, 2002). Using Wiki, blogs, and course management systems such as Blackboard or Moodle are instances for web-based teaching strategy. Concurrently, these tools facilitate management of students' assignments and administration of a course for instructors (Cole, 2009). Nevertheless, effective use of such technologies is still highly dependent on how well those are integrated with the rest of a lecture (Walker and Johnson, 2008). A critical challenge in the use of online technologies is the volume of information exchanged between students and a lecturer. Another widely advocated strategy of teaching is classified as student-centred instructional strategy and, as its name suggests, places students in the centre of the course design. In this strategy, methods including group discussion, in-class writings or contents, and student presentations are used to improve engagement and hence, learning performance of students (Felder and Silverman, 1988, Lam et al., 2016). Such methods have been ranked as the most effective techniques for learning from students' perspectives (Lam et al., 2016). The key to success in student-centred teaching is to ensure individual learning problems are identified through timely feedback and addressed effectively (Soh and Gupta, 2000).

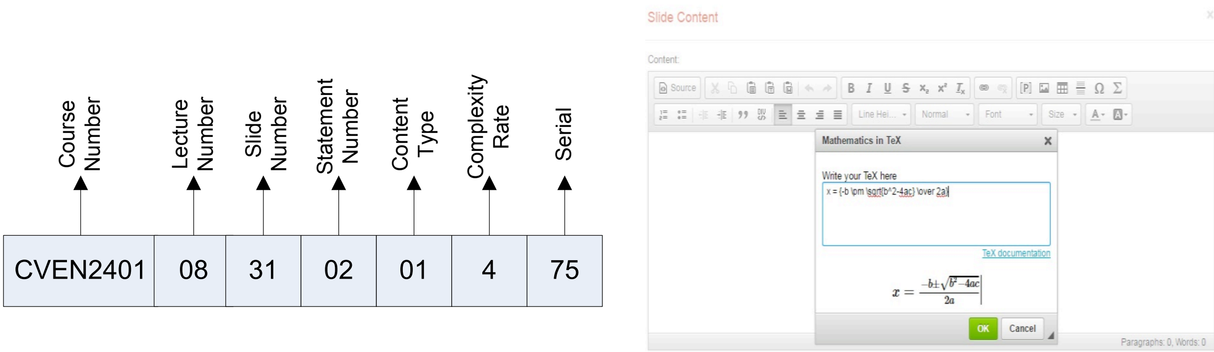
There have been serious concerns related to time shortage in implementation of such methods particularly when corrective feedback on students' performance is required (Akdemir and Koszalka, 2008). Blended teaching methods have been introduced to partly manage limited in-class time. Through combining online and face-to-face instructions, students are provided with a piece of mind to control their learning time and place (Meyer, 2003). A well-regarded instance of blended methods is flipped classroom in which most of interactions between students and teachers are switched to out-of-class time (Bergmann and Sams, 2012). Attending a class is then targeted to address learning issues of students mainly through group activities. Although beneficial to in-class time management, its success rests on self-regulated behaviour of students in managing in-class and out-of-class learning times (Lai and Hwang, 2016). This has perhaps been a major hindrance for academic institutions which seek to keep their teaching outcomes at a high and competitive level.

Instructional strategies and technology-assisted education can lead to improved learning performance and effective teaching if they are combined with a microscopic analysis of course content. As John Sweller (2015) conceptualizes, learning process is controlled by the capacity of working memory where information are processed and transferred to long-term memory as the main unit of learning in human brain. As a learner struggle to make a schema of information is being delivered to him/her in a limited timeframe, s/he would best raise questions and feedback on the points of ambiguities to facilitate learning process (Sweller et al., 2011). This can be the best point of departure to shape instructional strategies and provide a well-designed teaching material.

System architecture

The system is designed and developed on an online platform with three main features. Two of the main features are designed to serve the instructor with "lecture design" and "interactions management", while the third one is designed to assist students with their "learning process".

Through a "lecture design" module, the instructor starts by creating the teaching slides through following a systematic method which assigns a content-specific code to course contents. The content-based coding system is defined using the notion of cognitive load theory through which the type and the complexity of materials are determined (Sweller et al., 2011). Five typical course contents associated with distinguishable memory loads are conceptual, mathematical, graphical/ diagrammatic/ tabulated, general descriptive, worked-out/visualized example (Cooper and Sweller, 1987). Complexity of a typical course content is then determined by the lecturer via a five-point Likert scale from very easy to very hard. Corresponding to the type and the complexity of a specific section of a lecture, a numerical code is generated by the system which constitutes part of a full serial number representing course name, lecture number in a course, and slide number in a lecture, as shown in Figure 1.a. Concurrently, the system is an alternative to slide creation tools such as Microsoft PowerPoint in which the user can prepare the whole lecture, as a snapshot is shown in Figure 1.b. Within a single slide, the software enables the instructor to assess type and complexity of different statements independently provided that each statement conveys a separate type of message.



a) **Coding system** b) **Slide creation platform**

Figure 1: Coding system linked to teaching materials to create a structured database

Students can get access to the lecture materials after registering into the system. The basic function of "student module" is to provide students with the ability to study course materials and write feedback, ask questions, or leave comments on the content corresponding to a specific slide or a particular statement inside a slide, as exemplified in Figure 2. In addition, students can make an overall assessment about design of different slides. Due to its web-based platform, students are enabled to make their inquiries either during seat time or in out-of-class period.

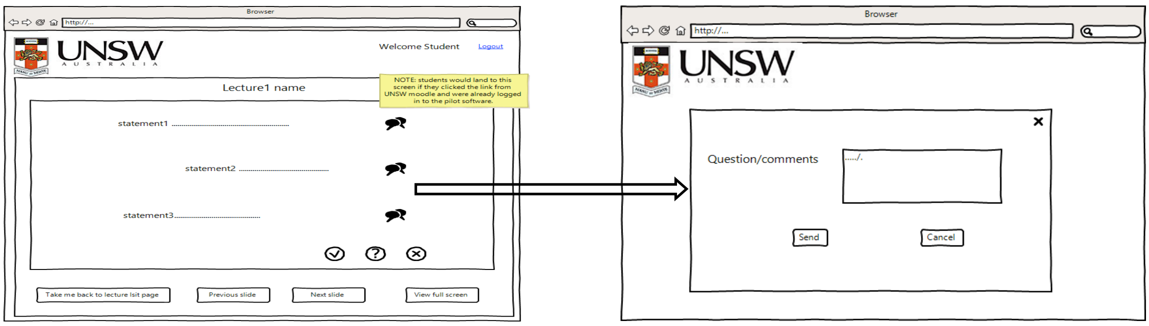
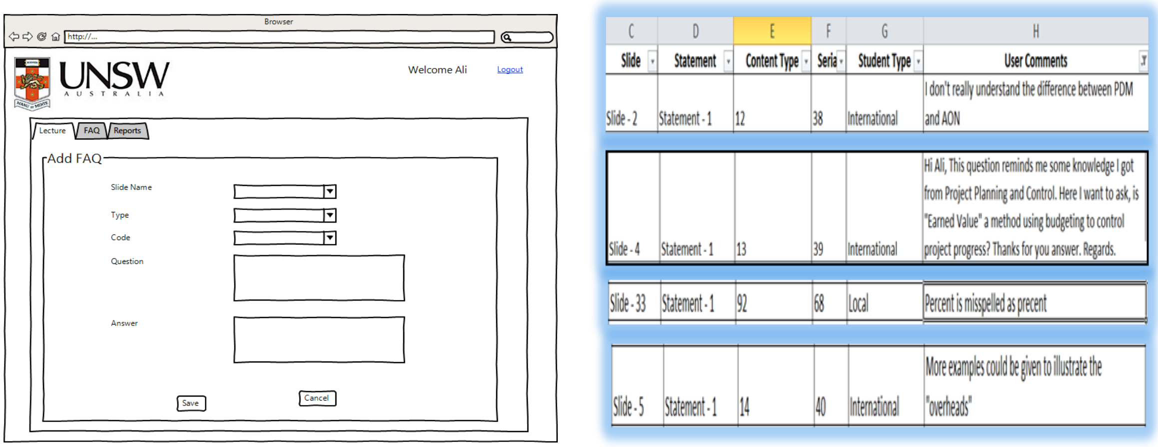


Figure 2: A wireframe view of query/feedback feature of the software

In "interactions management" module, the software provides the instructor with an unclassified and classified access to students' enquiries and feedback. Through unclassified access, the lecturer can access each single question and directly send an answer to an individual student. In such instances, the system specifies the section of the lecture that a particular query corresponds to, using the coding system. Under classified access, comments can be classified based on the section they are related to, type of materials, complexity of materials, and similarity of comments. Therefore, the instructor can opt to address such issues via class discussions, posting an answer to "Frequently Asked Questions (FAQ)" menu of a lecture, or both, depending on his/her assessment about importance of the issue. The system allows the instructor to quickly respond to comments with reference to a specific classification available in the database of the lecture. Figure 3.a shows a snapshot of an example interaction via FAQ.

In student module, a student can check the attended comments by the course instructor either in FAQ or through an independent response or modification in the lecture materials. On the other hand, the software can generate a detailed report for the instructor about participation of students in the course interactions through time spent on studying different lectures as well as their comments. Through the reporting system, the lecturer can instantly access a classified summary of the feedback/questions raised by the student demonstrating the exact section of the lecture, its type and complexity, its corresponding teaching strategy, and similarity of the student learning issues, as a sample snapshot is shown in figure 3.b. To address the queries, consequently, s/he can take a relevant corrective action during the same lecture, after a break time, or in the next lecture, depending on the type of teaching issue identified, i.e. teaching strategy, content type, and so on.



a) **FAQ feature** **b) Reporting feature**

Figure 3: Interaction through a) FAQ and b) reporting features of the developed software

Results and discussions

The proposed architecture was programmed and the created system went live on servers of the UNSW for a trial use. The trial use was aimed for an engineering course entitled “sustainability in construction” at School of Civil and Environmental Engineering. At implementation phase, the last four lectures of the course were designed and created using the online slide creation platform of the software. Further, 36 (comprising %50 international students) out of 109 students enrolled in the course were randomly invited to register and test the software for the aforementioned lectures. In parallel, the PowerPoint or pdf versions of the lectures were made available in the Moodle to the whole class, including the invitees, as usual.

Table 1: Statistics about type and complexity of teaching materials used in the lecture 7

Material type	Overall Composition (%)	Level of complexity (%)				
		Very easy	Easy	Medium	Hard	Very hard
Conceptual	24.5	4	15	37	35	9
Mathematical	2	100	0	0	0	0
Tabulated/graphical	27	18	11	41	24	6
General descriptive	29.5	23	29	40	12	0
worked out/ visualized example	17	0	36	59	5	0

As a principal outcome of using this system, course design process is facilitated through its analytical framework in which the lecturer can proactively assess teaching materials to ensure standards and strategies of teaching enforced by the institutions are met. Table 1 provides an example analysis performed on the first lecture created in this system, containing 46 slides. As shown, conceptual, mathematical, tabulated/graphical, general descriptive, and worked out/ visualized examples account for 24.5%, 2%, 27%, 29.5%, and 17% of course contents, respectively. Moreover, 65.2% of course materials are ranked in medium or higher levels as judged by the course instructor. This assessment is, however, based on subjective analysis of each section of the course and can be objectively related to the extent to which each section receives feedback and questions from students. Nonetheless, these initial statistics provide the instructor with an early insight about his lecture, its compatibility with institutions' teaching standards, and potential strategies that s/he may take to ease learning loads for students, such as increasing number of worked out/visualized examples and decreasing conceptual load of the content.

The trial use of this platform has increased engagement of students in the class discussions, compared to the first eight lectures, as observed by the lecturer. This improvement may be attributed to purposeful discussions triggered by comments that clearly refer to a known section of the lecture. In the trial use, the lecturer gave preference to addressing FAQs via oral discussions. This has led to higher participation level in back and forth conversations in the class as a whole, even though 63% of them have not used the platform. In other words, the activated contribution potential of students who had been using this platform has affected the rest to be involved in the lecture's interactions.

In addition, a dramatic increase is observed in content-specific feedback and comments raised by students when using the new tool, in comparison with utilizing Moodle platform as the existing interactive system. In Moodle, interactions between the lecturer and students in the selected course were dominated by administrative queries about the course and its assignments rather than a specific learning point. When a learning point was involved, it was a time-consuming process in order for the lecturer to screen such a query from administrative ones and then to recognize to which lecture and specific section in a lecture it refers to. Therefore, the response time may take several weeks, in some cases, to address a learning issue, if the question is not lost amongst numerous interactions. A late response, however, may become less effective as it needs a flashback to a subject covered previously in the middle of a newly opened topic. The new system has reduced the response period to nearly real-time, with maximum one week waiting. In addition, the reporting system used by the software, which provides the ability to categorize the questions and comments based on slide number, or a specific topic, minimizes the likelihood of comments or questions being overlooked.

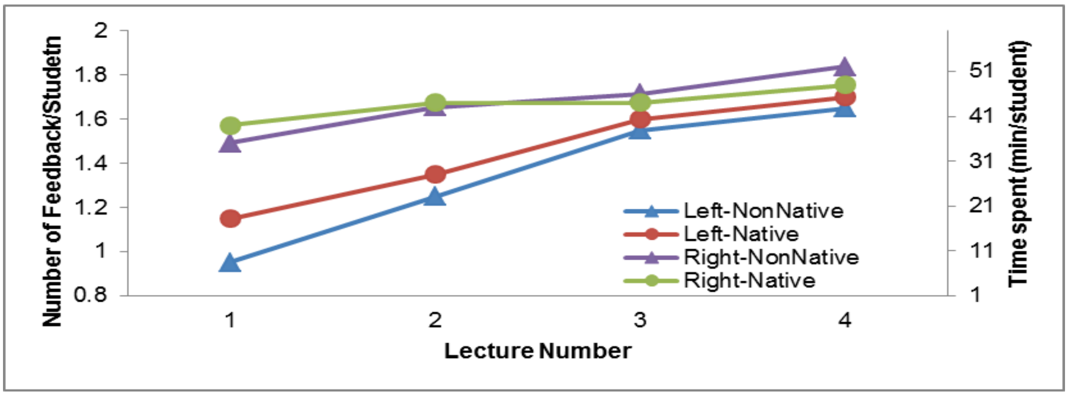


Figure 4: Trends of participation in the lectures for students with native and non-native English speaking background

The implementation of the software was observed to greatly increase the contribution of international students into class discussions, compared to the traditional teaching methods. This improvement was noticed by the course instructor in the last four lectures when the unanimous platform of the tool helped international students to confidently make their points about the taught materials. As shown in Figure 4, an increasing trend is observed in the use of the system in terms of both number of content-specific comments left by different students and the time students have spent studying lecture materials. While international students spent less time, accounting on average for 35 minutes, in the first lecture compared to native speakers of English in this course, their time contribution gradually increased in the next lectures and exceeded the contribution of the native group from the third lecture. Simultaneously, a progressive increase was observed in the number of comments/feedback they made in the lectures, reaching 1.65 comments per student which is almost equal to 1.7 comments per student on the side of local students.

The statistical analysis of interactions between students and the lecturer are in compliance with the aforementioned in-class observations. The increasing trend of students' involvement in the lecture can be correlated to real-time and purposeful addressing of students learning issues by the lecturer. In particular, international students acquire confidence when their contributions are acknowledged in the class. The developed software has reached its targeted goals for lifting student-teacher interactions to a real-time and effective level. It has also improved traditional practices of feedback collection which are currently performed after a teaching period and provide generic feedback on the overall quality of a course. Nevertheless, the web-based slide design process is quite time-consuming and needs to be improved in future developments.

Conclusions

A new architecture for real-time interactions between students and lecturers, particularly in large classes, was presented. Its main feature is to provide students with an ability to make content-specific feedback and comments about a lecture. Its second feature lies in an encoding system established on cognitive load theory of instructional design for framing teaching materials. A corresponding web-based system was developed using annotation technologies, which serves to the intended features of the proposed architecture.

The developed software was tested in a course taught at School of Civil and Environmental Engineering, UNSW. The outcomes have been satisfactory in terms of improving students' engagement and reducing the lecturer's response time to feedback and comments raised by students. On the part of international students, the software progressively encouraged them to confidently make learning points and participate in class discussions. These are mainly attributable to nearly real-time addressing of learning issues achieved through access to classified queries which refer to a specific section of the lecture. The structured analysis of course materials and students' feedback enabled by the software can be simultaneously used to update teaching standards and shape instructional strategies. Nevertheless, the developed software should not be considered as a panacea to any learning issue at its current stage, and future researches are required to make it suitable for a wider range of instructional methods.

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