Online quality control in Engineering education

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Structured abstract

BACKGROUND
Student feedback is valued and used in most higher education institutions. However, there are increasing concerns in the improvement of teaching effectiveness and learning quality. Higher education institutions traditionally use Student Evaluation of Teaching (SET) survey results as: diagnostic feedback to teachers about their teaching, a measure of teaching effectiveness for use in administrative decision making, information for students to use during subject selection, and use in research into teaching. Nevertheless, there are some characteristics of SET that are incongruent with established quality control theory and accepted sound practice in engineering, not the least of which is the off-line (retrospective) nature of SET as applied in education. It is therefore surprising that quality control strategies in engineering education have followed the same approach as broader higher education rather than adopting the established quality control models of industry.

PURPOSE
To investigate the potential benefits of adhering to established industrial quality control models (especially online quality control) in engineering education.

DESIGN/METHOD
Generally, the study approach is based on the Participatory Action Research model. But specifically, an automatic online survey system was developed and used in a semester of teaching a mechanical systems design unit. The response of the students and the staff were then analysed to find pertinent themes.

RESULTS
The results showed that through the use of online quality control academic staff were better able to determine the needs (learning and more broadly) of students as the teaching period commenced. Additionally, the needs could be satisfied within the teaching period by implementing changes as suggested by students and viewing the effects via the feedback provided. This is as long as the teacher views themselves as an integral part of the control system feedback loop.

CONCLUSIONS
In conclusion, the notion of online quality control reiterates the need for a faster cycle of feedback, quick action based on information received and verifying that changes made address the identified issues. Further, the current SET models (end-of-semester surveys) are not always helpful in ensuring that issues and misconceptions around learning are identified and addressed as quickly as the proposed online quality control model. Ideally, the teacher should be an integral part of an ongoing quality control system to ensure full benefit.

KEYWORDS
online quality control, student evaluation of teaching, student engagement and learning

Introduction and background

There are increasing concerns from both students and educators regarding the perceived efficacy of the ubiquitous teaching and learning survey. This is particularly so with respect to the improvement of course contents and the delivery of higher education courses. These concerns include, among others, lack of flexibility and focus (Kember, Leung, & Kwan, 2002), obscurity of meanings and contexts behind feedback (Freeman & Dobbins, 2013), and the inability to capture complex, transformative learning processes through surveys (Bramming, 2007). A more salient issue centres on the premise that surveys neither encourage real-time collaborative discourse between educators and students nor do they encourage student-to-student dialogue around learning (Freeman & Dobbins, 2013) (McCulloch, 2009). Certainly, failure to encourage interaction and dialogue around learning is particularly undesirable. This is more so given that current conceptions of active learning as student-centred (Biggs, 1999), and good feedback practice (Juwah, Macfarlane-Dick, Matthew, David Nicol, & Smith, 2004) have emphasised the importance of fostering students-educators and peer-peer discussions around learning.

However, despite the many concerns that have been raised with the traditional model of survey evaluations, it is noteworthy that not many works have gone into improving the practice. Perhaps it is already concluded that the actual problem lies with the appropriateness of using survey as a feedback tool (McCulloch, 2009). The authors also noted during a review of the literature that there is little empirical work that has examined the use of either web-based or paper-based surveys as an online quality control tool in a university classroom. It actually seems that the notion of using surveys at a higher frequency is something thought to be avoided. For example:

> *It would seem sensible to collect feedback on students' experience of a particular educational activity at the completion of that activity, since it is presumably their experience of the entire activity that is of interest. In other words, it would be most appropriate to seek student feedback at the end of a particular course unit or programme of study* (Richardson, 2005).

Within this paper, the authors use the notion of *online quality control* to underscore the primacy given to collecting information for immediate improvements in the quality of student engagement and learning in the next class session. This is in line with Taguchi's conception of total online quality control (Taguchi, Chowdhury, Wu, Taguchi, & Yano, 2004). The authors assume that because the reader is likely an engineer and quality control has its origins mostly in engineering systems, they will have some familiarity with the quality control theory that has become dominant within engineering industry. However, for completeness, the critical elements of online quality control include: continuous process diagnosis, corrective adjustments, feedback and feed-forward control, preventive maintenance, and control of process conditions (Taguchi et al., 2004).

It is the notion of continuously monitoring and responding to issues that is implicitly opposed to the traditional practice of collecting information at the end of the semester for administrative and future improvement purposes. Throughout this article, we refer to the more traditional practice as *offline quality control*.

Purpose

This evident lack of research into the potential benefits of online quality control within education calls for more empirical studies to highlight nuances of the online quality control approach in education and to explore possible areas for future research. In this article, we share our experiences attempting to apply online quality control using a web-based survey system for enhancing the quality of student engagement and learning in a large mechanical systems design class.

Methodology

The survey tool

The authors designed a survey tool that first focused on the general level of satisfaction that the students have with the teaching and learning. Then, once the level was known, focused on what is working well and what is not (regardless of what aspects of the teaching and learning processes they might be). The authors felt that such an approach would allow for speedy use and response, which is essential for weekly use. Because the first focus is on a single measure it can be investigated quantitatively. However, because the second focus could be about any aspect, a qualitative approach was deemed more appropriate.

The final questions that the authors chose for the survey were:

1. Do you like the teaching staff?
2. Do you like the subject material?
3. Are you satisfied with the teaching quality?
4. What about the subject do you like and want kept?
5. What about the subject would you like to see changed?

The first three questions were YES or NO questions, while the last two questions were open-ended short essay questions.

The first two were to allow students to vent personal dislikes that were considered peripheral to good teaching. It was not felt essential at a tertiary level for students to like their teaching staff or even the respective subject itself. Additionally, while the authors know that such things can affect teaching and learning, they are also outside of the scope of this study. However, liking or disliking either could affect their response to what was deemed to be most important so it was included to help with the accuracy of measurement. The authors note that this was not their development; it is an approach that they had been introduced to earlier by others during their academic careers.

The third was considered the more important question as it allowed the instructors to track students' satisfaction with their learning experiences. The reason why only 'yes' or 'no' were allowed for these questions is that this enables for a rate of satisfaction to be plotted on a continuous chart throughout the semester. This allows for easier determination of trends in satisfaction – much like a control chart used in quality control. Further, by asking only for 'yes' or 'no' it is possible to find a distribution for the satisfaction rate of the population from a sample. This can be used to account for the statistics of small numbers. Finally, if a Likert scale is used, then there is basically a non-parametric distribution, which makes averages effectively meaningless. Essentially, anything other than 'yes' or 'no' was going to detract from the goal of emulating quality control systems. This is not to say that the authors feel that this is the best approach – it is simply the one that, on balance, seemed best for this project.

In the last two questions, open-ended probes were used to elicit subjective views on learning preferences: what worked for the students and what needed to be changed. Furthermore, the open-ended form of the last two questions afforded opportunity for students to reflect on specific issues they had troubles with and in turn provide critical information to the lecturer on myriad issues that needed to be addressed. By noting what issues were raised, the lecturer could ascertain the aspect of teaching and learning that needed to be improved without the need for a large survey designed to cover each aspect.

Survey tool delivery and monitoring

The online quality control tool used was a self-resetting (weekly) survey (with the questions covered in the previous section) that was run through www.thequalityprofessor.com. The comments and results of the survey itself provide insight into how students and the teaching and learning in general were affected by the use of the online quality control system. The lecturer also kept a journal of the weekly discussions and his understanding of students' needs. The journal and the students' weekly responses on the survey form the basis for recording classroom collaborative reviews and deliberations used for later analysis.

Analysis method

The comments by the students in the survey and the comments in the author's journal were reviewed concurrently for consistent themes. This was done by both authors and only those themes that both agreed were present were recorded. Once these themes had been identified, they were then linked with theory where applicable, to provide an improved understanding of how the use of online quality control affects teaching. It is important to note that the first step is inductive whereas the second is deductive. Thus, if the research were repeated by others, extra themes might have been identified.

Context

This research project was conducted in semester 2, 2012 at a university in Victoria, Australia. The subject (which will now be referred to as 'the subject') that was used to test the online quality control system is a fourth year mechanical engineering design subject. This subject is designed to create an immersive experience that replicates a real-world design project scenario in the classroom. It also affords an opportunity for students to take charge of their own learning and development within engineering design. The overarching goal of the subject is to develop awareness within each student of their design abilities as well as pertinent skills they need to develop in order to further improve their design abilities. A key design ability that was developed and monitored throughout the semester was their ability to convert generic problems into appropriate engineering problems – known as framing. To achieve these, students were given an assignment that involves the design and construction of a physical system that needed testing. They were also introduced to various design cognition theories. In addition, students were taught various engineering systemic topics (thermal systems, energy storage systems, pressure vessels, etc.) that provide context for the design theory that is covered and are also good for mechanical engineers to be aware of prior to graduating. After the majority of their design activities had been completed in the subject, students then wrote an assessable reflective piece on their learning as well as their perceptions of their design abilities.

Participants and participation

All 160 students that were enrolled in the subject for semester participated in this study. All were asked to complete weekly reviews of teaching quality and the learning activities via an online survey tool. Students were emailed weekly to remind them to take the survey and to provide them with a link to the ongoing results. The results included an on-going graph of the proportion that responded either positively or negatively to the first three questions and all comments made. The results of each week were reviewed in the following lecture. This constituted a collaborative review (involving the lecturer and students) of the understanding of the comments had by the lecturer and the planned actions based on that understanding. It should be noted that not all students would complete the survey, but they would still be part of the review if they attended the lecture or later watched the recording of it. Collaborative reviews were particularly helpful for determining whether the responses reflect the views of the broader student cohort. The reviews also helped establish a common understanding of issues that had been identified. The weekly participation numbers are shown in table 1.

Table 1: weekly participation

Week	1	2	3	4	5	6	7	8	9	10	11	12
Number	20	21	8	9	9	6	1	5	2	2	3	1

Results

After the analysis of the survey responses and journal was conducted, the following themes were evident:

- Ongoing clarification of student needs
- Concurrent diagnosis of learning issues and corrective adjustment
- Student-teacher dialogue

- Student-student discussion

Ongoing clarification of student needs

At the start of the teaching semester, students complained about the use of mind maps in the lecture. In response, the respective author pointed out in a following lecture that mind maps were used to provide an overview of the entire system being considered and to show the links between ideas. This in turn was to encourage systemic thinking, which is a vital skill for expert design engineers (Cross & Clayburn Cross, 1998). In a later survey response, students then indicated that the real issue was that they found the mind maps boring. In response, the respective lecturer added images to make the mind maps more engaging – this should have already been done if the lecturer were following the established rules of effective mind maps (Buzan & Buzan, 1993). In this case it was realised that the students needed more visual stimulation than they were getting.

The subject required students to form groups that were made of multiple disciplines and student backgrounds. Comments in the survey showed that some students had issues due to a lack of diversity in tute groups or not having an established social network. In response, an online forum was set up on the subject website to assist students. Subsequent surveys indicated that not all students were using the forum. Thus in a following lecture time was allocated to identify students looking for groups and groups looking for a certain type of student. Based on past experience, the authors are sure that this issue would have taken longer to be identified and dealt with, and the negative effects would have been much greater.

Concurrent diagnosis of learning issues and corrective adjustment

One interesting aspect of using the online quality control system used is that it allowed continuous identification and resolution of learning issues as well as other peripheral impediments and bottlenecks around learning.

A key focus of the subject was framing. Framing is the manner in which one views the problem and then decides about how one will solve it. While the notion of framing is not complex, understanding one's own frame (for an engineering design problem) and then expressing it has proven to be a challenge for students when first introduced to it.

In week 1:

> *Framing seems to be quite a vague concept still. Asking around everyone seems to still not be too sure what exactly the outcome of framing should be.*

This was considered normal based on past experience, but it allowed for pointing out that this was normal at first so that students did not feel they were performing below expectation.

In week 2:

> *More detailed description of what framing is.*

This revealed that some students were in need of a description that was different from what had been used so that it made sense to them. The explanation was then changed in the following lecture to increase the proportion who understood what framing is.

In week 3:

> *Problems at the end of the lecture are good to get an understanding of the best way to go about framing*

By week 3 it seemed that students were beginning to become comfortable with what framing was and were indicating what helped to become better at it.

In week 5:

> *I am confused on the concept of "framing" a question, from what I thought framing was when you can see the problem from different points of view and different angles and give a list of different possible reasonable engineering solutions to the one problem, then from the list of solutions formed see which one is most viable and effective for the situation and apply it. While in the last lecture I was given the*

impression that you should only pick one solution to the problem and just stick with it, which makes me ask the question, are we framing the problem or just pushing our own point of view without seeing the problem from a different perspective?

There were still some students who were confused by it though. However, the survey revealed that it was not vagueness of the concept anymore. It was now the use and role of framing that were the issues of contention. This was easily covered in the following lecture.

In week 6:

Frames are good for people who aren't good at being creative, but for those who know what they're doing..... not so much.

By week 6 it could be seen that the students felt comfortable enough with framing that some could questions its importance in the subject. Thus the student need was now to understand its use in a greater context and knowing that it was more than a creativity tool. After week 6 comments about framing had vanished and focused on other issues. The authors thus felt that the respective learning needs had been satisfied.

Student-teacher dialogue

While similar to the ongoing clarification of student needs, student-teacher dialogue was related more to peripheral aspects of the subject that were not explicitly taught, but still important for students to know. As an example, some students argued that the style of teaching should be made more linear and made more similar to the teaching style of other subjects (recall that the cohort is made of students learning engineering design). The argument of one student was:

It is easier to change 1 person to suit many, than change many to suit 1 person.

This statement implied (based on the context of the greater submission from which it came) that the lecturer should accommodate what the students wanted. This provided an ideal introduction for a conversation on the need for students to change if they wanted to improve. Further, it was a chance to point out that the type of change that might be required to improve design cognition would not be an easy or comfortable one. Based on comments in the journal kept by the respective author, this dialogue naturally arose after the student made the above comment.

Another example of how online quality control encouraged this dialogue was related to the assessment and its purpose. In the past the authors have noticed that some students were happy to do well in some parts of a design report (those they enjoyed and were better at) and not others (those they disliked) so that they could still get a reasonable mark while only using skills they already had. In response, a marking system that allocated the lowest mark of those allocated to each section as the final mark was used. The intention was to encourage an equal attention to each part of the design report. This was not received well by some students:

The marking criteria I think is completely stupid….. This does not reflect how well the student has understood the majority of the subject, it only shows that he/she sucks in overall because he/she may not have done as well in one topic.

This then promoted further dialogue on the nature of professionalism and how students get good marks. The first topic centred around the phenomenon where as successful as a person might be, they are often remembered for what went wrong. This can be especially so in engineering where a small error can cause an otherwise perfectly design machine to fail. Once again, this was not an explicit part of the subject, but it was still considered by the authors to be an important and valuable topic to be discussed with the students. The second topic prompted the sharing of a study technique. Although it was lowest section mark that was allocated as the final mark, a rubric was provided for each section indicating how full marks could be had. Students who had gained full marks in the past were those who read through the report prior to submission and noted the elements that satisfied each part of the rubric. This was to ensure that full marks would be had. Some students who did not get full marks were then able to successfully protest by bringing in marked up copies of their reports

to show how they satisfied the rubric. This was a study technique that appeared to be unknown to many of the students. The author who took the subject as the lecturer noticed an improvement in reports after this conversation was had. This too was not a part of the subject, but talking with the students about how to satisfy criteria was considered to be beneficial for the students.

The authors are sure that the above comments would not have otherwise been known without the survey being used. As one student pointed out:

> *Teaching staff say they are approachable although they can be intimidating.*

The above student would have been unlikely to have said this in person to any teaching staff. However, they could say it via the online quality system. This is another example of how dialogue was encouraged. Although the authors were unsure how to be less intimidating, it was clear that the online quality control system allowed students to raise topics to be discussed when they might have otherwise not felt that they were able to.

Student-student discussion

The online quality control system also provided a forum for students to review their conceptions on learning in light of their peers' contributions. Given that the responses were opened to all students, students were able to read what others thought about the subject and respond with their own thoughts. This was not common, but it was present.

Week 5:

> *I don't care what people say, if you are up to speed with the book, then you know what [the lecturer] is on about, and you don't need silly google images to engage you.*

The above comments show that some students were feeling that other students were not engaging in proper study practices. This was only a single comment, but the fact that a student felt compelled to share their thoughts on study habits with others was considered noteworthy by the authors.

However, not all students seemed to value this at first. It should be noted that the lecturer did point out that some visual learners might appreciate the images and actually learn better with them.

Week 2:

> *I don't care about what other people said in this survey, this survey is for you to improve your unit, not for us to hear what other people think.*

This comment suggests that students might not appreciate that other student perspectives can help them. The lecturer pointed out this opportunity at the week 3 lecture.

Discussion

The ongoing clarification of student needs showed that online quality control allows for a greater level of specificity when understanding the challenges of the students. This could range from the very practical to actually understanding the learning style needs of students. However, this ongoing clarification appears to be reliant upon the lecturer viewing themselves as an integral part of the control loop – a number of times the lecturer had to respond to comments to verify needs. This came from the lecturer responding to issues with action and explaining why that action was being taken. Students could then respond to that action so that the loop continued to feed information around until a solution was had. If the lecturer were not to respond or not explain the response, then it is likely that the benefits of the online quality control system would not have been had.

Online quality control supports concurrent diagnosis and corrective adjustment to ensure that learning needs, as they change throughout a teaching period, are met. This is different from current offline models, which appear to focus more on retrospective inspection of quality. In other words, current offline models in higher education are tailored more towards offline quality control, which explains the concern of some researchers over its ability to capture

complex learning processes (Abrami, Rosenfeld, & Dedic, 2007; Bramming, 2007) . Thus, one important benefit of continuous quality regulation is that it provides avenues to ensure that the precise learning needs of the student can be met – explaining how to meet assessment requirements for example.

The dialogue between the teacher and the students shows that online quality control allows teaching staff to better understand peripheral and sometimes more abstract issues that students might have trouble dealing with – the need to change to improve is an example. Further, because students can feel that academic staff are intimidating, these issues can be raised using such a system. The key to this benefit is that the system is online and continuous. If the issues had been raised after the subject, then it is hard to imagine how the lecturer would have been able to respond.

Furthermore, online quality control does help students see their peers' perspectives on learning – students did explicitly comment upon this. The authors posit that exploring other people's thoughts and expectations around learning might allow students to understand their own weaknesses and strengths relative to others. It would be good to know what others think of a given idea so that one can question oneself. However, there is insufficient evidence to argue how this actually played out in this experiment. Nevertheless it the authors think it is of value and something that should be enhanced in the future.

Conclusion

In conclusion, the notion of online quality control reiterates the need for a faster cycle of feedback, quick action based on information received and verifying that changes made not only address issues that were identified, but also support student engagement and learning. Further, the current quality control systems for measuring student satisfaction and teaching quality (end-of-semester/annual surveys) are not always helpful in ensuring that issues and misconceptions around learning are identified and addressed as quickly as our proposed online quality control model. Therefore, the online approach is more congruent with proper quality control conceptions than what is currently the norm. However, for an online system to work, teachers must view themselves as active part of the control loop. Future research should focus on ascertaining more definitively the optimum time for deployment, techniques to get more students involved and how teachers can actively engage students through the process. By doing so, it will be possible to gain other benefits such as: understanding student needs temporally; understanding student comprehension temporally; identifying pertinent issues that are peripheral, and possibly otherwise ignored that students need covered; and encouraging student interaction to explore alternative perspectives on learning.

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