

Instantaneous Feedback in an Interactive Classroom

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Abstract $\frac{3}{4}$ A successful learning environment is one in which students and teachers easily interact, i.e., one in which students freely ask questions without any inhibitions and teachers know whether their students understand basic concepts. This is our vision of an interactive classroom and creating and maintaining this vision is a continuous process. Feedback is a critical component of this continuous process. Our main thesis is that interacting with students and giving them instantaneous feedback can be very effective in facilitating the learning process. The main advantage, real and active learning by students, far outweighs the potential drawback, namely that teachers have to cover less material in class since it takes time to collect and give feedback.

Index Terms $\frac{3}{4}$ Active learning, Engineering education, Instantaneous feedback, Interactive classroom.

INTRODUCTION AND MOTIVATION

There is much debate amongst educators over exactly what we should be teaching our students. In the context of engineering education, the question is: "what types of skills and knowledge should a graduating engineer in a specific engineering discipline possess?" The answer to this question certainly drives undergraduate (and graduate) curriculum decisions and degree program structure. We do not plan to enter the debate in this article, but let us consider what would happen if one were to ask this question to their colleagues. Our guess is that the outcome of collecting answers to this question would be a long list of topics and skills (ranging from basic science and math skills to general engineering topics to discipline specific topics), each of which someone would consider to be crucial and indispensable. While we believe that there probably is a core set of skills which a graduating engineer should possess, attempting to design a program which covered all these topics would most likely result in an overloaded work schedule for students, who already feel overworked.

So how can we resolve the "too much to teach but not enough time" dilemma all educators face? The solution may come from the recent paradigm shift happening in education, namely the shift in focus from teaching to learning. The dilemma of not having enough time to teach everything arises when the aim is to teach. However, when the aim is to facilitate learning, the challenge is to create an effective learning environment. In this paper, we will

address the issue of creating an interactive learning environment by collecting and giving instantaneous feedback to students in the classroom.

We first discuss the role of instantaneous feedback in creating an interactive classroom, then describe the process of both collecting and giving instantaneous feedback, and finally discuss the benefits and consequences of adopting this approach.

INSTANTANEOUS FEEDBACK IN AN INTERACTIVE CLASSROOM

A successful learning environment is one in which students and teachers easily interact, i.e., one in which students freely ask questions without any inhibitions and teachers know whether their students understand basic concepts. This is our vision of an interactive classroom and creating and maintaining this vision is a continuous process. Feedback is a critical component of this continuous process. By feedback, we mean instantaneous feedback. Non-instantaneous feedback, i.e., surveys and instructor evaluations, is familiar and quite common, but does not fully serve our purpose. Instantaneous feedback, i.e., indications of whether students understand concepts at the point of contact, works on a different time-scale, and, as we will argue, is more important in creating an interactive classroom.

Instantaneous feedback enables the teacher to intervene when a large portion of the students misunderstand a basic concept and clear it up quickly. This also enables students to get their questions answered immediately. The benefit of clearing up a question at the initial point of doubt is that it enables the student to actively participate in the remainder of the class and not dwell on unresolved issues. Instantaneous feedback is also fully consistent with the concept of active learning, in which students learn through both knowledge transfer and self discovery.

While it seems that getting instantaneous feedback requires the existence of an interactive class, there are ways in which teachers can get feedback immediately and, in the process, foster a interactive environment. There seem to be two mechanisms for getting feedback, electronic and non-electronic. Non-electronic mechanisms include polling and having students work in small groups to answer questions posed by the teacher. Electronic mechanisms include using personal response systems (e.g., Educue's PRS) or personal digital assistants (PDA) to enable interaction between students and other students and between students and

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teachers. There are several documented cases of teachers using electronic mechanisms to obtain feedback. The process of obtaining instantaneous feedback is time-consuming and results in less material being covered in class. This apparent drawback is mitigated by the fact that using and responding to instantaneous feedback can actually enhance learning since it causes students to ask questions and understand concepts they might have glossed over before. In addition, students perform active learning and learn to think critically.

In summary, our thesis is that the process of obtaining instantaneous feedback from students can create an interactive learning environment. Furthermore, teachers should continuously strive to obtain and give instantaneous feedback despite the effect the process has on the quantity of information that can be delivered in a class session.

FEEDBACK MECHANISMS

We believe that both collecting and giving feedback are a crucial part of any plan to create an effective learning environment. In this section, we investigate both instantaneous and non-instantaneous feedback and argue that while both are necessary, it is the latter which, by the very nature of its short cycle time, plays the more important role in interactive learning.

Non-instantaneous Feedback Mechanisms

Non-instantaneous feedback is delayed feedback. We often ask students to fill out a survey form at the end of the class. These forms often ask students to rate their teachers on specific items and to answer some general open-ended questions, such as "did you like your teacher?". Although students' responses to such questions may give us valuable information, they are useful only to assess the just-completed course and to improve the course for the next batch of students.

Other mechanisms for non-instantaneous feedback are examinations and assignments (often called continuous assessment), which do allow the teacher to collect and give feedback several times in the semester. The problem then seems to be that students focus on taking exams or doing assignments, and forget about learning, which is after all the main point. Now, the rational person will argue that well designed exams and assignment will inevitably lead to learning. While we do not disagree with this notion, it seems that this argument underestimates students, who often are so creative and hard-working that they will find a way to do the minimum amount of work without learning. In addition, a student is less likely to focus and struggle with a concept after the exam than before, unless he knows that concept will be examined again. Whatever the case, exams and assignments are useful for assessment and collecting some feedback, but it is not enough and not in time. What students need from teachers is timely specific feedback on the level of their understanding of basic concepts. What

teachers need from students is timely specific feedback on what fundamental concepts they do not grasp.

Instantaneous Feedback Mechanisms

We have basically come to the conclusion that the most important property of feedback for it to be effective in nurturing students' learning is that it must be in time, in other words, instantaneous. We now describe the notion of instantaneous feedback and discuss some feedback mechanisms and their benefits. Instantaneous feedback is based on the premise that it is best to clear up a misunderstanding or doubt at the point of occurrence. Somewhat arbitrarily, we categorize instantaneous feedback into electronic and non-electronic types.

Electronic feedback mechanisms represents an exciting evolution (or as some say, revolution) in educational tools. Modern advances in technology makes it quite feasible to collect feedback instantaneously. As an example, consider the Personal Response System (PRS) distributed by both Varitronix PLC and EduCue LLC. The PRS basically provides a simple electronic means to poll the students in a class. In a nutshell, the polling process consists of two steps: (i) each student responds privately to a question posed by the teacher, (ii) then all the responses are collected, analyzed, and displayed to the class as a histogram. The system consists of an electronic wireless (infrared) transmitter for each student, a centralized wireless receiver, and a computer with certain software to analyze and visualize the results. Furthermore, the PRS allows for an anonymous mode so that the responses of the students are unknown to both the teacher and to other students.

The main benefit of electronic in-class polling is that it gives students a safe way to participate in classroom activity. It gives students feedback on their level of understanding as compared to that of the other students in the class. It gives instructors instant feedback on whether the majority of students understand the essential fundamental concepts. The consequences to using a personal response system are that it takes both time in planning and time to implement in class. We discuss this aspect in the following section on benefits and consequences.

Another mechanism for collecting and giving instantaneous feedback is using personal data assistants (PDA) in class to simplify data distribution and visualization. Since modern PDAs intergrate wireless communication capability, they certainly can be used to implement a personal response system. It is not unreasonable to think that in the future, students will be asked (or at least encouraged) to purchase PDAs as part of their course of study. In fact, the National University of Singapore strongly encourages its students to buy laptops and has negotiated with vendors to provide very attractive prices for students. A similar situation is not unforeseeable for PDAs.

The final example of an electronic mechanism for collecting feedback is using the Short Message Service

(SMS) capability of modern telecommunication systems. Currently SMS use is exploding exponentially amongst younger persons and it is to our advantage that we use students' affinity for SMS to facilitate the learning process.

While we only gave three examples, the possibilities for electronic instantaneous feedback are endless. In addition the use of electronic tools in the classroom is rising slowly. As an example, consider the use of PRS in the classroom. A quick search at www.google.com results in a plethora of web sites describing the use of and experience with PRS in university education, e.g., Chemistry [1], Economics [2], and Engineering [3], to the use of PRS in secondary schools [4]. The next killer application for wireless communications may well be education.

While these electronic tools and mechanisms are potentially an exciting educational tool, it is important not to forget that the main point is to stimulate student learning. It is also possible to collect and give instantaneous feedback through non-electronic means. One such method is question and answer sessions, including both the scenario where students ask the teacher questions and where the teacher questions the students. The problem with question and answer sessions is that if students freely asked and answered questions, we would have no problem to begin with. The reality is that students are often hesitant to ask or answer questions in class in fear of looking unintelligent in front of their classmates.

So, we need to then find other ways to encourage (or even trick) students into participating in class. One useful technique is polling the class, namely asking a question, presenting several answers, and asking the students to support one of the answers by a show of hands. It seems that some students are more willing to take a risk if they see other students are also. Another technique is group problem solving sessions, in which students work in small groups to solve a problem, and then elect one member to present the solution. The final suggestion, which is one of my favorites, is the multiple choice quiz game. The teacher designs a multiple choice quiz (with both easy and challenging questions) and uses it as the basis for a quiz game, not unlike the ones we see on television. The students, divided into two teams, compete to see who can answer the question faster and the team who answers the most questions correctly wins. My experience is that students do participate in games like this and based on feedback (the non-instantaneous kind), they find it stimulates the learning process.

BENEFITS AND CONSEQUENCES

The use of instantaneous feedback mechanisms for collecting and giving feedback has several benefits, the main one being that students learn actively, and one potential drawback, namely that it may reduce the amount of material which can be covered in the classroom. However, we maintain that the advantages far outweigh the drawback. In

fact, the benefits of active learning render the drawback meaningless, since students will then be able to learn on their own what we did not teach them.

Instantaneous feedback enables the teacher to intervene when a large portion of the students misunderstand a basic concept and clear it up quickly. This also enables students to get their questions answered immediately. The benefit of clearing up a question at the initial point of doubt is that it enables the student to actively participate in the remainder of the class and not dwell on unresolved issues. Innovative methods of collecting and giving instantaneous feedback, such as polling, also provide a non-threatening way for students to participate in the classroom discussion.

As previously noted, the process of obtaining instantaneous feedback is time-consuming and results in less material being covered in class. This apparent drawback is mitigated by the fact that using and responding to instantaneous feedback can actually enhance learning since it causes students to ask questions and understand concepts they might have glossed over before. In addition, students perform active learning and learn to think critically. The result is that students develop self-learning skills (in other words, they learn how to learn), and will be able to learn any additional material independently. This is certainly the position we want our students to be in, rather than the position of knowing and being able to regurgitate on demand only the facts and formulae we have fed them.

In a nutshell, our basic message is that the bi-directional flow of instantaneous feedback will create an interactive learning environment. Furthermore, teachers should continuously strive to collect and give instantaneous feedback despite the effect the process has on the quantity of information that can be delivered in a class session.

Finally, we note that the examples and suggestions for collecting and giving instantaneous feedback presented in this paper are only the tip of the proverbial iceberg. We believe that the possibilities are endless, and that we, as educators, must be innovative and respond quickly to the needs of our students.

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