Designing a technology-enhanced authentic learning environment for a large engineering class

Alberto Corrias, Martin L. Buist
Department of Biomedical Engineering
National University of Singapore

Swee Kit Alan Soong
Centre for Development of Teaching and Learning
National University of Singapore

A growing body of evidence suggests that one area in which new approaches have been a significant improvement over traditional teaching methods in tertiary education is where there has previously been a detachment between what is taught in the classroom and the real life scenarios where that content is used. For this reason, the creation of authentic learning environments in tertiary education has been advocated over the last decade. The literature now provides the necessary theoretical framework and boundaries of what can be defined as an authentic learning environment.

Here, we present the design of several teaching practices aimed at creating an authentic learning environment in a large undergraduate engineering class. In particular, we leverage on various technological tools to overcome the inherent difficulties of providing an authentic learning environment in the presence of a large group of students.

Keywords: authentic learning, engineering education, video recorded lectures, large class

Introduction and theoretical background

The authentic learning paradigm has recently emerged as one of the most popular constructivist educational experiences. The basic underlying idea is deceptively simple: learning improves when conducted in an environment designed to be as close as possible to the real environment where the subject matter will be used. It is plausible to assume that the recent popularity of authentic learning environments is due to the notion that a considerable amount of teaching in tertiary education was deemed ineffective because it did not follow this underlying idea.

A precise definition of an authentic learning environment has emerged in the last decade (Herrington & Herrington, 2006). The successful implementation of authentic learning environments have been reported in various disciplines including economics (Perry & Reynoldson, 2006), history (Glendinning, 2005), biology (Koenders & Cowan, 2006), and literature (Fitzsimmons, 2006). A fully detailed discussion on the definition and boundaries of an authentic learning environment is beyond the scope of this paper. For a concise but comprehensive list of elements that an authentic learning environment is supposed to possess the interested reader is referred to Meyer (2009) and Herrington Reeves and Oliver (2010).

Here, we present the design of an authentic learning environment aided by the use of technology. The scenario is a large undergraduate class of about 100 students. We consider the list of elements of an authentic learning environment that are provided by Herrington Reeves and Oliver (2010). In particular, we will present how technology can be integrated according to some of the elements of authentic learning design recommended by Herrington, Reeves and Oliver (2010). For example, they state: "providing an authentic context that reflects the way the knowledge will be used in real life" (p. 19), "providing authentic tasks and activities" (p. 21), "promoting articulation to enable tacit knowledge to be made explicit" (p. 32) and "providing coaching and scaffolding by the teacher at critical times" (p. 34).

From traditional to authentic

The undergraduate course under consideration is a core course in an engineering curriculum focused on data analysis techniques. This is both a traditional and foundational topic in engineering. It has been taught for several decades in practically all engineering schools. At the end of this type of courses students are expected to understand the statistical theory underlying the data analysis as well as being able to apply it. As a consequence, the traditional way of structuring the learning environment for such topic is to organize the contact sessions with the students into two stages: first, the theory is explained, and this is followed by a series of simple examples that illustrate how the theory is applied. Often these two stages are defined as lectures and tutorials, respectively.

Although this approach is reasonable and has its merits, it also has several drawbacks. First and foremost, explaining the theoretical part takes a significant amount of class time. This results in very limited time remaining to devote to illustrative examples. In fact in many engineering courses, the total time spent in tutorials is half of the total time spent in lectures. On top of that, the time constraints also force the illustrative examples in the tutorials to be small, clearly defined problems that have the sole aim of making the students understand the otherwise obscure theoretical formulas.

Proponents of the authentic learning environment framework argue that small, clearly defined problems are not representative of real life problems, which are typically ill-defined and with uncertain boundaries. On the other hand, proponents of a traditional framework argue that incorporating realistic, ill-defined problems into the teaching framework is impractical and ultimately not feasible in a university environment (Herrington & Herrington, 2006). To clarify the point of view of the proponents of the traditional framework, we consider the engineering data analysis course as an example: after explaining the theoretical part of data analysis there would only be little time left for illustrative examples, typically confined to tutorial sessions. Complex and ill-defined problems, albeit more realistic, would require longer time frames that are incompatible with a typical university schedule. This, according to the proponents of a traditional framework, would make an authentic learning environment not feasible and impractical.

Here, we propose several technologically-enhanced teaching practices that aim at reconciling the need for an authentic learning environment with the constraints of a traditional undergraduate schedule and class size. Notably, we do not propose any measure that reduces the amount of theoretical knowledge being taught as this form a fundamental aspect of engineering training.

Provide an authentic context that reflects the way the knowledge will be used in real life, with the support of video recorded lectures

This section describes how an authentic context could be provided in the large class, with the support of video recorded lectures. Figure 1 illustrates the differences between the proposed technology-enhanced authentic framework and traditional class framework.

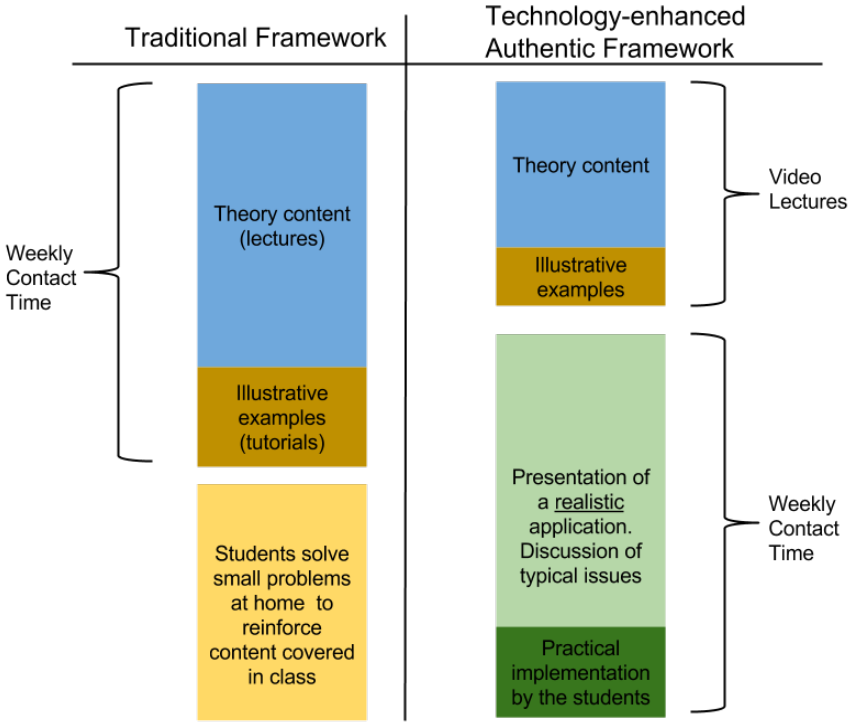

Figure 1: Use of video lectures to facilitate class discussion of a realistic problem.

Note that weekly contact time is the same in the two frameworks shown in Figure 1. The video recorded lectures are pre-recorded and made available to the students for viewing at least one week before the contact session. These video recorded lectures provide students insights of the theoretical content as well as a set of small illustrative examples. Students are required to prepare themselves by viewing these online resources prior the face-to-face class. The fact that small illustrative examples are covered in the video lecture in the authentic framework allows for more time to look at realistic implementation during the contact session. The classroom time therefore begins with a presentation of a realistic problem that will be discussed during the session. Following, the remaining time is used to deal with all the uncertainties and complications that an ill-defined realistic problem typically presents.

To clarify the transition from traditional to authentic learning, we consider one particular topic of the class (linear regression) as an illustrative example. The traditional way of teaching this topic would be to start the lecture with a presentation of all the mathematical formulas that underpin linear regression. This can easily take up an entire lecture. During the tutorial, students will be shown small illustrative examples of some application of linear regression.

In the proposed new design, the mathematical formulas that underpin linear regression will be covered in the recorded video lectures. The face-to-face session then starts with the presentation of a real case scenario where data analysis (of real data) using linear regression is needed. Students are encouraged to think as if they were research engineers and their boss just dropped this data on their desk to be analysed. The session would then proceed with discussing the requested steps to perform the requested data analysis. Such discussion can be performed with the whole class or by dividing students in smaller groups and ask them to think about possible solution strategies.

Authentic tasks and activities

As the classroom time is devoted to the discussion of a realistic application of the theory, it is also possible to design tasks for the students that are realistic. Taking once more the engineering data analysis course mentioned earlier, this translates into giving students a real set of data to analyse. This is in contrast to an artificial set of data created to prove a point or support a particular part of the theory. In a university engineering department, real data are typically easy to obtain because there are many laboratories engaged in various areas of research. As modern data analysis is performed on computers, this translates into dedicating part of the weekly contact time to a session in the computer rooms where students are presented with real data to analyse and are given some time to try to solve the problem before being guided towards the solution.

The practical session can be scheduled in what used to be traditional tutorial session. It is noteworthy that the technology-enhanced framework we are describing does not imply any change in the actual schedule of the class. This is particularly convenient in the very frequent case where the class schedule is imposed by the institution and is difficult to change.

Technology to help providing coaching and scaffolding by the teacher at critical times

Apart from coaching and mentoring students in the class, it is important to ensure that students have a basic understanding of the theory covered in the video lecture before the contact session in the classroom. Online self-assessment quizzes can be used to help the student gauge whether they understood the contents of the video lectures. Questions should be designed around the content of the video lectures. The nature of such quizzes should be formative. The supporting technology should be able to let the student see the correct answer after taking the quiz. The ability to take it multiple times and record the score each time is also critical.

These formative quizzes are very valuable for the purpose of creation of an authentic learning environment. They provide a valuable form of scaffolding of the learning process. First, the lecturer can estimate, before the classroom contact session, the parts of the video lecture that were least understood by the students and more emphasis can be placed on those parts. Second, regardless of their score on the test, the student who took it will be better equipped to be engaged in the classroom session and benefit from it.

Besides online formative quizzes, technology may help the scaffolding of the learning process in other ways. For example, online chat rooms or forum can be established for each self-assessment quiz. By looking at the types of questions and topics being discussed in the forum or chat rooms, the lecturer can shift the focus of the upcoming classroom session towards the parts that were more debated in the online forums or chat rooms.

Enhanced articulation to enable tacit knowledge to be made explicit

As mentioned, at the beginning of the contact session, students will already have watched the video lecture. The realistic scenario discussed in class will be an application of that theory. Consequently, there will inevitably be several moments during the classroom presentation where students are able recognize parts of the theory they watched in the video being applied. At such moments, the lecturer may stop and ask students questions that can easily be answered by anyone who has watched the video lecture.

This practice has two benefits. First, it promotes articulation of knowledge in the classroom and second, it tends to make classroom sessions livelier and more interactive.

Conclusions

We have proposed a design for an authentic learning environment in a large engineering class. We propose that the use of technology, video lectures in particular, can be an important factor in providing an authentic context in the teaching process.

The scenario we have discussed, an engineering data analysis class, is quite common in any engineering discipline. The engineer has to be trained in the theoretical (i.e., mathematical/statistical) aspects of the subject as well as the details of the actual implementation. We propose to shift the theoretical part to video lectures that are made available before the classroom session. This frees up the contact session time for the discussion of a realistic application of the theory. The use of other technological tools, such as online self-assessment quizzes, forms an integral part of the proposed design. It is noteworthy that the teaching practices that we are proposing can be applied to any number of students and does not require any change in the class schedule. Also, we do not suggest any reduction in the theoretical content of the course. This is important as it would be unwise to construct a realistic and authentic learning environment at the expense of the underlying theoretical content.

In the future, it could be interesting to monitor the implementation of the proposed technology-enhanced authentic learning environment and try to evaluate its impact on student learning. To do so, one could compare student performance before and after the implementation of the framework described here. Seeking students' opinion via a survey or a small-group discussion could provide further evidence of the utility of this implementation of an authentic learning environment.

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