Enhancing Class Learning using Computer-based Design Tools

Andi S. Putra*

*Engineering Design and Innovation Centre
National University of Singapore
Singapore 117576

*Corresponding Author’s E-mail: engpas@nus.edu.sg

Keywords: Computer-based; Design tools; Core Subjects; Design Module.

Extended Abstract

Introduction
Transformation of education – including engineering education in particular – has been the recent concern in education and industry communities, with a call to integrate the “science” and the “application” through design. The engineering curricula, for instance, have traditionally been based on an engineering science model, where a solid foundation of core subjects (including mathematics and sciences) are taught in the first half of the curriculum, and then only followed by engineering and application subjects in the second half of the curriculum. Many studies have pointed out that such approach does not allow the engineering concept to sink in (Dynn et al., 2006).

The availability of computer-based design tools in the form of software and apps has provided an avenue to address this issue. Computer-based design tools, which are sometimes provided for free, offer reliable, much faster solution and thus allows many concepts to be taught and fostered with many examples of implementation. This in particular addresses the following problems:
1. That students, when learning theories, tend not to comprehend the context of their applications
2. That students, when solving problems, tend not to comprehend the underlying theories of their own solutions

Module in the Traditional Curriculum
Engineering curricula traditionally teach foundational/core modules in the first two years of four years curricula. The final two years of the curricula consist of application modules where students apply the theories that they have learned in the previous two years. In mechanical engineering, for example, the foundational modules including dynamics of motion and strength of materials are taught in year 2, while the application modules including machine design are taught in year 3. This curricular structure is presented in Figure 1.

Figure 1: Traditional engineering curriculum

Figure 1 depicts the gap between the teaching of the theoretical concept and the implementation of such concept, which can lapse for one semester or more. The rationale of such curricular structure is
to allow students to understand the concept/methodology prior to implementing it. Teaching the methodology and its application at the same time indeed require a longer time with traditional approach.

This structure, however, often creates a disjoint between the theory and the application. Students often learn important concepts without understanding the context in which such concepts are valid. Problems/tutorials somewhat can help, but they are simplified and hence do not present the complexity of real problems. Such theoretical understanding poses a big challenge for students and lecturers alike in year 3, where students are supposed to apply their knowledge to solve problems. Students often do not know where and when to apply certain concepts, and in many instances even forget about the concepts. This situation requires the lecturers and students to revisit the subjects in year 2 in details, but with much shorter time.

There are currently increasing numbers of computer-based tools for design, analysis, presentation, and other computational tasks that used to require human’s direct involvement and used to take a lot of time to perform. These tools are often available for free or at a very low price to download/use. Such tools present an opportunity to address the abovementioned issues. It allows very rapid generation of examples and analyses when there is a need to quickly revisit foundational concepts.

The integration of such tools to the design module in year 3 is discussed in the following sections.

**Class Preparation and Delivery using Computer-based Design Tools**

The intended learning outcomes of the design module are as follows:

1. Ability to translate concepts/ideas into engineering design using appropriate tools and methodology
2. Ability to build and test design solutions through appropriate validation methodology
3. Ability to analyze and interpret information

Students are given certain problems and are tasked to provide solutions using the knowledge/skills that they have acquired from their earlier years of study. This typically requires students to perform many analyses and to demonstrate many examples of application, in which they will need to recall what they have learned.

In the traditional pedagogy, the learning recollection is purely the responsibility of the students, or sometime with very minimum assistance from the teaching assistants. Using computer-based design tools, a new pedagogy is introduced where lecturers revisit the relevant foundational topics by means of examples of implementation, embedded in the current lectures; which are still retained for its efficacy (Charlton, 2006). Therefore, this does not require the change of the syllabus.

The approach allows rigorous subjects such as kinematics, dynamics, and strength of materials be taught in the context of engineering design and real projects. This approach can strengthen students’ comprehension of the subjects from typical theoretical understanding to contextual comprehension.

In the class that the author has been teaching, Autodesk® Force Effect and Autodesk® Force Effect Motion apps are used in the class, and the examples cited in this paper are based on those apps. However, other software and tools can also be used with the same philosophy.

A short example is presented here to illustrate how the objective is achieved. The force diagram in Figure 2, for example, could take 5-10 minutes to do manually, but would only take seconds using computer-based design tools. This allows students to get the correct design information and still concentrate on the bigger design problem (as opposed to only solving this particular calculation and then forgetting why they solve this problem). At the same time, this allows students to invoke their memory of the concepts they previously learned and comprehend the application of such concept.
**Evaluation**

This approach has been tried for one year to engineering students. At the end of the sessions and at the end of the module, students were requested to provide feedback; as follows:

1. It helps them in understanding the application of the concept of statics and mechanics.
2. It helps to link the theory of statics and mechanics with their application.
3. It helps to expedite their project when it reaches the design stage.

Additionally, students also share suggestions for improvement as follows:

1. They'd like to have a few rounds of interpretation familiarization to bring them up to speed to the instant results using the abovementioned apps/software.
2. They'd like this to play a role in assignments rather than in tests.

The design outcomes from the modules were more comprehensive, in that students performed deeper analyses of their design and were able to articulate and present their analyses in the reports; in comparison to the outcomes by their seniors.

**Conclusions**

This paper presents the rationale and the implementation of teaching and learning using computer-based design tools. It is a new initiative which has many areas of improvement, such as evaluating the effectiveness of the approach from various dimensions (e.g. achieving the learning outcomes, student experience, etc.).

Although its implementation has only been done within engineering curricula, it is implementable in other disciplines as well, as this approach only requires the availability of computer-based tools; such as the widely available statistics tools.

**Acknowledgement:** The author thanks Engineering Design and Innovation Centre (EDIC) and Autodesk® for their support.

**References**