Adaptive Tutorials using eLearning Platform for Solid Mechanics Course in Engineering

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Abstract: *The paper presents the concept, development and outcome following the development and implementation of a set of interactive teaching and learning tools for Mechanics courses in Engineering. The tools are designed, using Adobe Flex and Flash software and are hosted on the Adaptive eLearning platform (AeLP). The tool focuses on the strengths of conveying information by means of high interactivity, timely and adaptive feedback that tailors to the user's needs and places the user in challenging but practical mechanics scenarios related to the real world. Three different eLearning tutorials were created and the interactive tutorials were scripted for teaching and assessment purposes in Solid Mechanics and Engineering Mechanics courses in Mechanical Engineering, The Adaptive Tutorials have proved to be a major teaching medium that has been accepted by the student community for better understanding of the fundamentals.*

Introduction

Today's 21st century students need more explanation and understanding of the course than the book-and-board can provide. The majority of the students want to see that the learning outcomes from the subject be simple, easy and achievable. In general, the students are keen to correlate the subject matter with the engineering reality and they want to explore opportunity to visualize the subject matter through the experiments or similar exercise which would have demanded clear understanding of different components of the course of engineering. The students can learn the basic skills with the development of a coherent approach to computer-assisted learning and assessment (Hadgraft, 2007). Doing hands-on or interactive activities improve the students' motivational levels in learning (Packard et al., 1998 and Jorgenson, 2006). Moreover the research suggests that students benefit from an interactive learning environment in which they can have some control of their learning experiences

(Chandler & Mayer, 2001). Computer-based games that have been developed for the students in Statics and Mechanics of Materials courses (Philpot et al., 2003) appear to have improved student performances in the targeted topic areas. Although there are a number of initiatives by many Universities around the world to use the on-line educational tools, there are not many tools available which can provide an instant feedback to the student while maintaining teacher's reflection and adaptation with minimum effort. The paper is aimed at the development of a set of interactive learning tools known as Adaptive Tutorials (AT) developed on Adaptive eLearning Platform (AeLP), which does not only target the teaching of mechanics concepts and theories, but does so in an engaging, interacting and interesting manner. The tool is based on a few essential criteria including visually engaging graphics, user-friendliness, high interactivity and the ability to produce adaptive feedback that tailors to the user's actions and responses, with the target audience being University students undertaking Mechanics courses in 1st and 2nd year of engineering.

The development of eLearning tutorial is primarily targeted with the following objectives:

- Development and implementation of a set of Adaptive Tutorials that will act as supplementary materials as well as means of assessment for a mechanics related courses.
- Development of a Learning Object (LO) that is versatile for both the end-user and the lecturer of the courses that enables provision of timely feedback autonomously based on user input and is reusable for other courses with minor changes.
- Development of interactive capabilities to enhance teaching of the subject, which may include but are not limited to graphic, visual and interactive functionalities.
- Create a platform of learning that students can rely on to aid them through examinations, as well as to grasp and apply concepts and theories of Solid Mechanics through direct interaction with simulation and animation.

The development of the eLearning tool in this paper contains three main sections:

1. Implementation of Adaptive Tutorials (AT) using the Adaptive eLearning Platform (AeLP).
2. Development of Adaptive Tutorials for a mechanics related courses
3. Results and findings following implementation

Implementation of Adaptive Tutorials using Adaptive eLearning Platform

The Adaptive eLearning Platform (AeLP) developed by the eLearning research group at the School of Computer Science and Engineering of the University of New South Wales, is used for the implementation of the tutorials using the Adobe Flash and Flex software. The AeLP has three core features that differentiated it from other available platforms (Be-Naim et al., 2006).

The following are the distinctive features in selecting the AeLP:

1. Ability to provide timely feedback to students which are the core feature of this platform.
2. Ability to track scoring to allow for assessments.
3. Possesses the flexibility to alter content as the editor deems suitable.

Development of Adaptive Tutorials for Solid Mechanics Course

This section covers the production and design of the interactive tutorials for Solid Mechanics course in engineering at UNSW. As most aspects and concepts can be visualized, the development of this module required much consideration to enable the effective conveying of ideas by means of animation and simulation. The modules developed are visually and controllably rich since the utilised programs and platform yielded few production limitations.

Following steps are adopted in developing the Adaptive Tutorials:

1. **Determining the Learning Objectives (LO)**
   Learning Objectives are the desired results from attempting these Adaptive Tutorials. The objectives for each tutorial are determined from the course outline for a Solid Mechanics course in mechanical engineering at UNSW.

2. **Storyboarding**
   Storyboarding is the process of creating a series of illustrations that is displayed in sequence for the purpose of pre-visualising the tutorials. This process determines the flow of questions, outcome of the student's response and feedback for each question, the function and appearance of each required Learning Objectives (LO) of the entire tutorial to meet the objectives determined earlier. This process should be as detailed as possible to facilitate creation of the LO.

3. **Creating the Learning Objects (LO)**
   First step in creating the LO is to design and create the appearance by using the software Adobe Flash CS3. Another software, Adobe Flex Builder 3, is used to develop various types of user-interfaces and control the LO created through by means of a programming language called Actionscript 3.0. The LO is programmed to be controllable from the AeLP for the next stage of the development.

Scripting of Questions in the AeLP

The completed Learning Objective is uploaded into the AeLP as a Tutorial Session, and the questions can be scripted using the AeLP authoring environment. The question text, question properties, initial and applied states of the LO and feedback are all prepared at this stage.

Three different modules developed are:

(a) Bridge Module for clear understanding of shear force and bending moment concepts in beams with various loading conditions (Figure 1),

(b) Torsion Module to visualize and analyse the shafts experiencing torsion and to draw the torsion diagrams (Figure 2) and

(c) Mohr's Circle Module (Figure 3) to clarify the conceptual understanding of stress transformations and its requirements for further use.

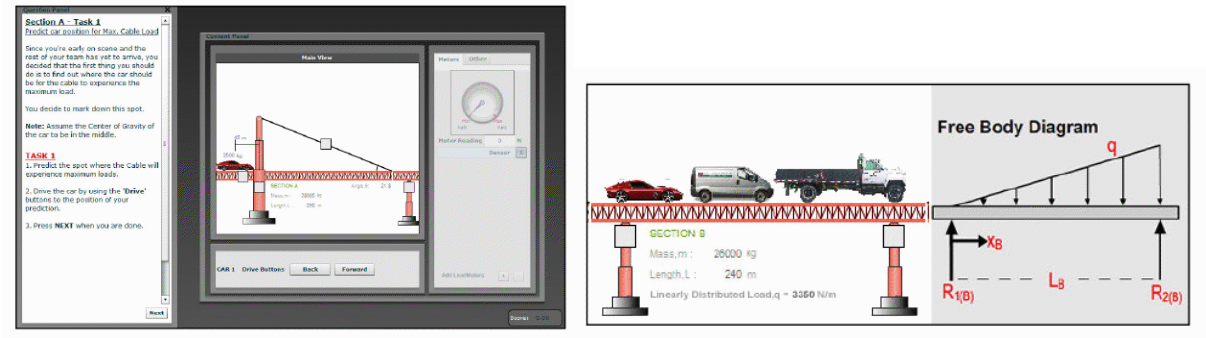

Figure 1: (a) Bridge module, (b) A span of the bridge showing the linearly varying load

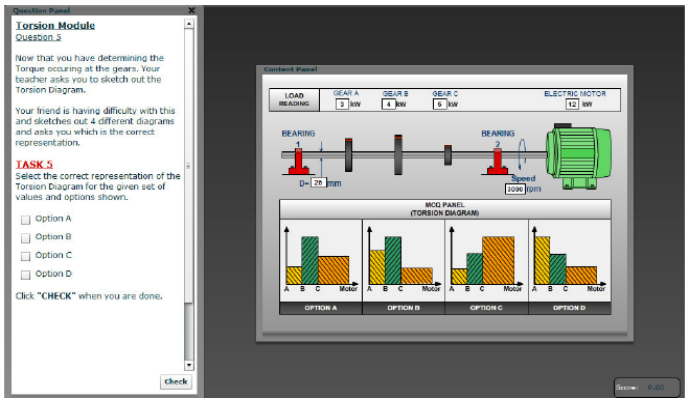

Figure 2: Torsion module

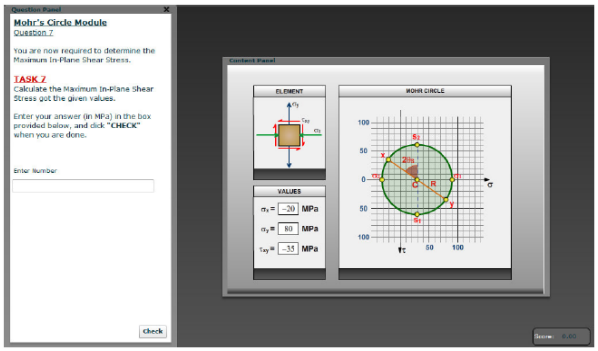

Figure 3: Mohr's Circle module for stress transformations

Planned development of a series of such modules is intended to complete the coverage of the entire Solid Mechanics course. The tools developed have the flexibility to tailor to other courses such as Engineering Mechanics. This is achieved by simple changes into the tool. One of the important aspects implemented in these tools is to include the randomization procedure which creates a separate example for every student.

Results and Findings Following the Implementation

Since the development of such modules, an implementation of using these exercises in the large-class teaching of Engineering Mechanics and Solid Mechanics courses in the first and second years of Mechanical Engineering has been effected. The implementation stage of the Bridge Module was broken down into two stages, as described below:

1. Released results from 1st launch:

The Adaptive Tutorial was released for a Mechanics course as part of the curriculum. The first stage was released to students towards the end of the semester, a stage where the students are more advanced for this level of expectations in the adaptive tutorial. The aim of the launch was to gauge the suitability and performance of the Bridge Module as an assessment and learning tool, and to obtain the students' feedback on the experience and the concept of the Adaptive Tutorials by means of a simple questionnaire and open text feedback. A total of 191 students attempted the Adaptive Tutorial with an average mark of 78.2%. The results of the questionnaire are analysed (Ho, 2007) as shown:

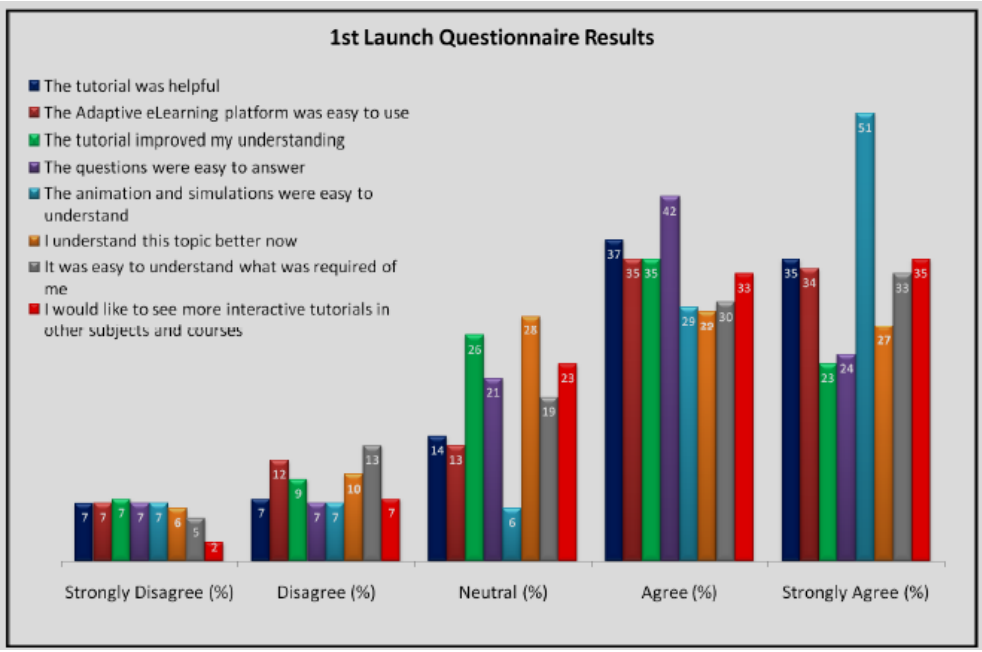

Figure 4: Analysis of results from the 1st launch

The responses from the open text feedback identified a few areas of improvements which included the removal or irrelevant interactive actions, improved feedback with solutions if stuck, and improving the overall user experience through minor text changes and layout of the questions.

2. Released results from 2nd launch

A modified version of the 1st launch was implemented as a learning and assessment tool for the students in the 2nd year, Mechanics of Solids course at the start of the semester. The aim of the launch is similar with the 1st launch, but also to gauge if the improvements made from the analysis of the 1st launch of the Bridge Module has indeed improved the tutorial as an assessment and learning tool. A total of 178 students participated in the second launch with an average mark of 80.5%. The results of the questionnaire are analysed (Ho, 2007) as shown:

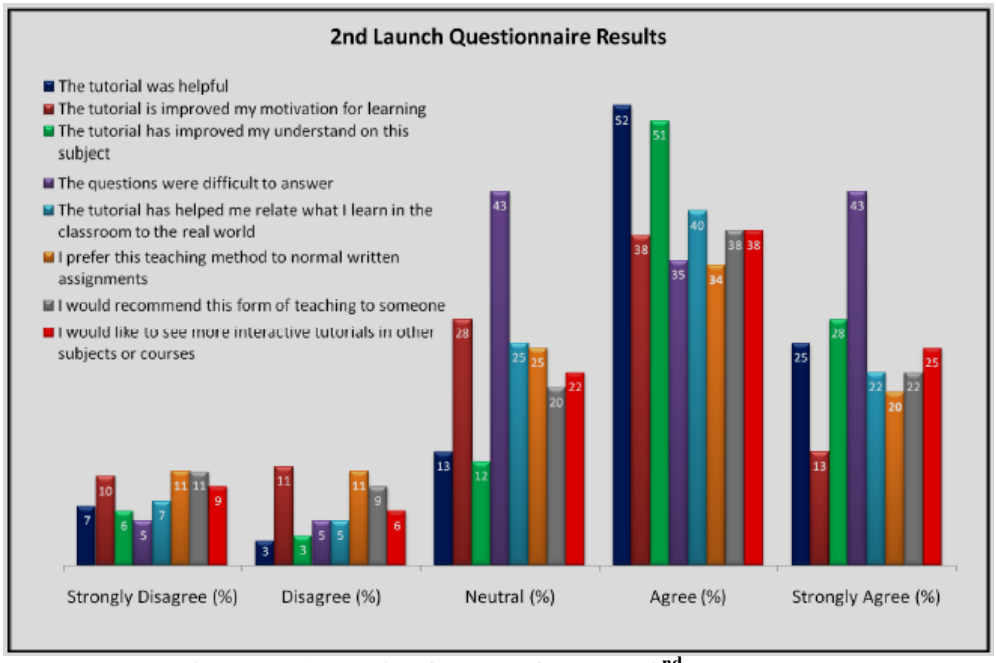

Figure 5: Analysis of results from the 2nd launch

The responses from the open text feedback identified further areas of improvements that included modifications to the user interface of the AeLP, and human-error in the solution of the question during the scripting.

3. Findings

The 1st launch results showed that only slightly more than half agreed that the tutorial improved their level of understanding. This can be attributed to the release date as the module was designed to be given to students in the beginning of the session as an assignment to refresh what they learned before. As expected, there was a significant increase that the tutorial improved their level of understanding and fewer "disagreed" in the 2nd launch. This shows that the release dates of the tutorials are very important and the best time for release is when the students have just completed the topics in class. From the results obtained from both launches, the majority of the students found the Adaptive Tutorial to be helpful, easy to understand, user friendly. Most importantly, the students were very interested in the Adaptive Tutorials as a form of teaching.

Conclusion

The development and implementation of Adaptive Tutorials, using the Adaptive eLearning Platform (AeLP), was successfully carried out for the Mechanics courses in Mechanical engineering. This has greatly improved the development process of the Adaptive Tutorials due to the rich graphical display, simple nature and user friendliness of the platform. Implementation of the tool was justified by trial

runs of the adaptive tutorials in two-phase basis into one of the Mechanics courses at the University of New South Wales. The outcome and feedback received were promising and the project has achieved its target of garnering interest in students and academics alike. The focus of the tool should remain at the development of visual and interactive material which would allow students to observe the scenarios and situations posed, therefore improving their overall understanding and method of thinking, thus building a solid foundation in the subject.

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