P005

The wheel has already been invented: facilitating students' use of existing mechanics resources

Thomas Goldfinch (tom_goldfinch@uow.edu.au), Anne Gardner (Anne.Gardner@uts.edu.au)

University of Wollongong, Australia; University of Technology, Sydney, Australia

Abstract: *We've been teaching engineering mechanics to first year engineering students for a long time, yet at many engineering faculties around the world there are still significant failure rates… Educators have tried many different approaches to address persistent high failure rates in first year engineering mechanics courses. These approaches often involve the development of new mechanics learning resources in a variety of styles depending on the perceived learning obstacle. As part of a project funded by the Australian Learning and Teaching Council on addressing student learning diversity in engineering mechanics we have developed a framework for reviewing these existing learning resources. This framework has been used to create a database of references to resources, categorising them by attributes such as topics covered and depth of coverage, suitable student learning styles, appropriate learner levels, copyright and accessibility issues. While it is anticipated that academics will use the database to complement their normal subject delivery, it has been developed with student users as the main target audience. Student focus groups have shown that independent study can be ineffective, particularly after hours when assistance is unavailable. The aim of this database is to encourage students to be proactive in improving the quality of their learning by assisting them to select learning resources best suited to their needs, in both content and style of delivery. In this paper we describe the elements of the framework used to review engineering mechanics resources, the resultant database of resources, and the planned evaluation of its effectiveness in improving learning outcomes. The authors intend to demonstrate use of the database at the conference.*

Introduction

Introductory engineering mechanics is a subject area studied by students from many engineering disciplines in the first year of their degree program in Australia and elsewhere. In short, these courses consist of an introduction to the basic methods used by engineers to analyse the action of forces on and within rigid bodies, in both static and dynamic frames of reference. It seems that in Australia and around the world many students are struggling with these courses, with failure rates ranging up to 50% (Rezaei, Jawaharlal, Kim, & Shih, 2007).

In response to this issue, a team of engineering educators (the EngMech team), funded by the Australian Learning and Teaching Council, have set out to determine what can be done to improve learning by addressing diversity in introductory engineering mechanics students within the constraints familiar to many engineering educators. This paper presents a resource for use by both students and academics that is intended to make locating and accessing alternative mechanics learning resources simple, relevant and effective, and avoids 'reinventing the wheel'.

Background

Many different causes of high failure rates in mechanics subjects have been cited, along with a plethora of attempts to solve the problem, some more successful than others (Goldfinch, Carew, & McCarthy, 2008). As Goldfinch et al (2008) point out, many of these efforts focus on addressing one or two areas. These can include the academic's pet topic(s), student motivation and engagement, learning and cognitive styles, prior learning, curriculum structure, or approaches to teaching and assessment. However, a common theme that emerged from the literature is the limited success that appears possible with efforts to address a limited number of problem areas. The EngMech team's own research into potential causes of poor student performance in engineering mechanics has also demonstrated the complexity of the problem. With many potential contributors to students' difficulties in mechanics, none have clearly arisen as dominant factors likely to produce substantial improvements if addressed (Goldfinch, Carew, & Thomas, 2009; Thomas, Henderson, & Goldfinch, 2009).

With a key objective of this research project being to improve pass rates in mechanics courses; it is clear that a narrowly focused approach, while useful for some students, would be unlikely to achieve more widespread benefits and, hence, overall improvements in pass rates. The EngMech team decided that an approach that utilises the wide variety of previous work that exists has the potential to combine some benefits of each.

Many efforts to improve learning in engineering mechanics incorporate the development of new learning resources to support existing teaching practices. The development of such learning resources has continued to such an extent that there are numerous mechanics learning resources already available for access online by students free of charge (Hadgraft, 2007). This is indicative of the increasing availability of open courseware in the higher education sector (Carson, 2008).

With such a variety of learning resources available for students online, the question is raised, how do we encourage students and educators to make use of these? A simple list of links and references to resources is unlikely to engage the kind of interest from students and academics needed to benefit the learning of many, particularly those already disengaged with the learning environment. What is needed is a more structured approach to finding and utilising these resources.

Student Perspectives

In a recent qualitative study by Goldfinch et al (2009), it became evident that some students were not aware of the alternative learning resources that were available, even text books. When asked to describe what changes they would like to see in the first year engineering mechanics course, students appeared to be selecting a 'best of' the educational methods and resources they had already seen. Moreover, when asked about their approaches to study, their study habits seemed to be an ill fit with the help that was available (ie. solitary, out of hours study when tutor assistance is unavailable), leading to hours of ineffective study. A recent study by Steif and Dollár (2009), indicated that students who demonstrate self-regulation of learning are more likely to perform better in engineering mechanics. However, Steif and Dollár also note that it is necessary to reward and encourage this self regulation with appropriate educational resources.

Alpay et al (2008) studied engineering students' motivation as they progressed through their degree and found that self reported motivation decreased substantially over the four years. Many students reported this to be due to, among other factors, a lack of interest in their studies and a perception from academics that teaching is not a priority. This issue of staff interest in education is one that many engineering educators will be familiar with. Chen et al (2008) argue that the actions of staff have substantial impact on the behaviour and engagement of students, positively and negatively. Felder and Silverman (1988) also suggest that teaching approaches can be misaligned with many students' preferred learning styles, limiting the efficiency of the teaching/learning process.

Here can be seen a few broad issues: students are often unaware of alternative options for learning and may be persevering with resources they are already familiar, or have been presented with; disinterested lecturers and tutors may be limiting learning by demotivating students; any given approach to teaching is unlikely to be effective for every student, and; students should be encouraged to take responsibility for their own learning. Considering these issues, the authors hypothesise that making a variety of existing alternative learning resources accessible to students will be of great benefit to them. In particular, the authors would like to investigate if this approach will:

- Assist students in becoming familiar with other learning options
- Encourage students to utilise resources that better suit their preferred approach to study
- Effectively circumvent disinterested educators
- Reward students who do self-regulate their learning and make the effort to seek additional help

The approach to encouraging students to be pro-active in their education also aligns with the graduate competencies of our professional accreditation body, Engineers Australia, particularly that graduates should be able to: "Take charge of own learning and development…" *(*Bradley*,* 2006*).*

Resource Evaluation Framework

With all of this in mind, the EngMech team set out to locate as many existing and freely accessible online learning resources as possible. Upon finding resources, the researchers looked for key attributes of each resource that define what type of learner they would be suitable for. This developed into the Resource evaluation framework.

Resources were evaluated according to criteria which included the following:

- Depth of coverage
- Learning styles catered for
- Type of knowledge emphasised
- Suitable Study Patterns
- Appropriate learner level

More pragmatic issues such as copyright or licensing, the file format, ease of use and topics covered were also recorded for each resource.

The appropriate learner level recognises that students can access resources for different purposes depending on their existing knowledge of the material and what stage they are at in their studies. The student wrestling with understanding basic concepts will be looking for different material to the student who thinks they understand the concept and is looking for problems to test their understanding, and the student looking to revise before an examination will be looking for a different type of material again. From this perspective the resources were classified according to five levels: pre-university, commencing, guided practice, revision and/or advanced. The majority of the resources evaluated so far are most suitable for 'guided practice' and/or 'revision', although there were some significant resources suitable for 'commencing' mechanics students.

Resources were also classified according to whether they seemed suitable for students working by themselves, or whether it was something that they could work on with other students. Academics looking for resources for a tutorial or hands-on session can also search on these terms. Most resources evaluated were suitable for independent study by an individual student but could also be used by an academic for a planned tutorial situation, and many of the resources have practical exercises for students to try, but with varying degrees of interactivity and feedback.

Reviewers also assessed the type of knowledge the resources addressed. Some resources contained mainly conceptual information, while others largely consisted of lists of steps to follow to, for example, draw a free body diagram. From this perspective resources were classified as procedural or conceptual, and abstract or contextual. This classification also has some alignment with the learner level criterion and the learning style of the student.

The learning style of a student will also affect the usefulness of a resource for that particular student. The authors realise that not all students will be familiar with the concept of learning styles or know how to classify their learning style. However, it is included as one of the review criteria as an increasing number of students are becoming aware of the way of learning that suits them best. As a consequence of the global push to increase the number of people that study engineering, we will have an increasing diversity in the types of engineering student we see in our classes. The authors see this diversity as positive for the profession, but as educators we should address the diversity in learning styles. Highlighting existing resources that cater to a particular learning style that students can access themselves will assist them in understanding material and takes the pressure of academics to address **all** learning styles in **every** lecture. The learning styles chosen in this review are largely based on the work of Felder and Silverman (1988) and learners are classified as: active or reflective, sensing or intuitive, visual or verbal, and sequential or global. These are not all mutually exclusive, for example a resource that shows every detail of a step-by-step procedure would appeal to both sensing learners and sequential learners. However, there are differences such as reflective learners can cope with more text-based material and less interactivity than active learners, who would also benefit from the resources classified as ‘hands-on’. Some resource authors have taken advantage of the advances in computer systems to handle a variety of file formats to include video footage, animated graphics and other ‘bells and whistles’ to appeal to different types of students. The authors welcome this development and expect it to continue as technology continues to become more user friendly.

The depth of coverage of a topic or topics in a resource is also assessed in the review. Four levels of depth of coverage are used depending on the level of detail in the explanation and whether relevant fundamental mathematics concepts or processes are included as well as any underlying mechanics principles that the new material builds on.

Mechanics Resource Database

A variety of resources are available with topics covered ranging from a whole syllabus to one particular topic eg. two dimensional truss analysis. This variety is useful as not all students are the same, and even one student can need different types of resources depending on their stage of study. However, the problem for students then arises as to which resources might be most useful for them at their particular stage of study. This necessitated the development of a database of evaluated resources aimed at assisting students with this problem.

The database is aimed at being accessible by any student or instructor. We would like to think any student would find mechanics material interesting, but realise that the database will primarily be of interest to engineering students. The database has a log in function to allow an individual’s use of the database to be tracked, and to collect demographic data about users. The tracking function is to allow us to determine which resources are being used, by whom and how often. The database also includes a means to allow user rating of resources so that it becomes an interactive document. It is envisaged to be an ongoing compendium of information and links to information on engineering mechanics as new resources are evaluated and added to the database. The initial list of resources reviewed was largely influenced by the list compiled by Hadgraft (2009). The authors recognise that this is not a definitive list, but it was a convenient place to start.

The database contains some explanatory material on various sign conventions and systems of units used in different communities so that students can either avoid resources that don’t align with the systems they are working in, or can ‘translate’ between their own system and the one used in the resources on the database. Not knowing why your shear force or bending moment diagram is the opposite of the one shown on the screen can sidetrack students from understanding the global concepts of internal actions. This is not to say that we should not worry about sign conventions, but should recognise that they are just conventions, the bending moment’s magnitude and direction are not affected by whether we call that direction positive or negative. Similar issues arise with variations in terminology for vectors ie. *a*, **a**, â are often interchangeable between texts.

Database Implementation and Evaluation

An alpha prototype of the database will be made available during the first semester of 2010. Student evaluation of the usefulness of the database is planned to occur in at least two universities in the second semester of 2010. At this stage the evaluation will be a paper-based self-reporting of student use. Limiting the initial evaluation to the universities where the authors are employed will allow us the option of linking the student responses to subject results. The evaluation will be aiming to determine the characteristics of the resources that students found assisted them in their understanding of mechanics concepts, and how self reported usage of the database is reflected in student grades.

Discussion

With an ever diversifying student cohort, a means of catering for students with different academic, cultural and socioeconomic backgrounds is becoming more and more necessary to ensure that as many students as possible achieve the required learning outcomes for engineering mechanics courses. While the authors argue that a database of learning resources may contribute to achieving this, there are some issues that have been considered which may work against its success. An argument has been raised in the past that students want to be 'spoon fed', and won't go out and use such a resource independently. This will of course be true of some students, but many are already pro-active in their study habits, others are unaware of the existence of other learning tools or may be reluctant to look beyond what their instructor has recommended, and some may have become demotivated trawling through a series of unsuitable learning resources. With testing and evaluation it remains to be seen just who will use and benefit from the database. At the very least, the database is likely to be of use to students already excelling in their studies, particularly with the adoption of the 'advanced' learner level option.

The Learning Styles evaluation criteria also present some issues. Litzinger et al (2007) point out that a number of studies have disputed the assertion that matching learning styles to teaching methods (or instructional resources) will result in significantly improved learning, and that there is a lack of evidence to support this. In response, Litzinger et al suggest that educators should use the learning styles concept as a way of ensuring that there is balance in an educational program. The authors agree with this, and believe that the database of learning resources will make this process simpler by providing an easy route for finding a wide variety of instructional approaches. It will also allow students to discover what learning resources work for them beyond the 'best of' list mentioned earlier, and encourage the diversification of study approaches.

In using the database, the authors also believe that students will be given the opportunity to become more aware of higher education outside their own institutions. This could lead students to become more critical of their educational opportunities and experiences, in turn, becoming more conscious of their learning. With the original intention being to improve learning in introductory engineering mechanics, it seems there are potential educational benefits beyond the topic level. With further research and development, it is hoped that the extent of these benefits may become clearer.

Summary & Invitation

In response to high failure rates in first year engineering mechanics course, a team of engineering educators, funded by the Australian Learning and Teaching Council, have set out to address diversity in introductory engineering mechanics students by making available a simple to use database of existing learning resources. Through the comprehensive evaluation of the learning resources referred to in the database, the students can quickly access material likely to be of most benefit to them in terms of depth of coverage, learning styles catered for, type of knowledge emphasised, suitable study patterns, and appropriate learner level. While its success is still to be evaluated, the authors believe rewarding students for seeking alternative learning options is a good way to encourage such practices throughout their studies.

Evaluation of learning resources and population of the database is an ongoing process, and the authors would like to invite engineering educators to contribute resources they have created or come across.

References

Alpay, E., Ahearn, A. L., Graham, R. H., & Bull, A. M. J. (2008). Student enthusiasm for engineering: charting changes in student aspirations and motivation. *European Journal of Engineering Education, 33*(5-6).

Bradley, A. (2006). *Australian Engineering Competency Standards - Stage 1 Competency Standards for Professional Engineers*. Engineers Australia, Melbourne.

Carson, S. (2008). The OpenCourseWare Story: New England Roots, Global Reach. *The New England Journal of Higher Education, 23*(1).

Chen, H. L., Lattuca, L. R., & Hamilton, E. R. (2008). Conceptualizing Engagement: Contributions of Faculty to Student Engagement in Engineering. *Journal of Engineering Education, 97*(3).

Felder, R. M., & Silverman, L. K. (1988). Learning and Teaching Styles in Engineering Education. *Engineering Education, 78*(7), 674-681.

Goldfinch, T., Carew, A., & McCarthy, T. (2008). Improving Learning in Engineering Mechanics: The Significance of Understanding. *19th Annual Conference for the Australasian Association for Engineering Education, 7-10 December, Yeppoon Australia*.

Goldfinch, T., Carew, A., & Thomas, G. (2009). Students Views on Engineering Mechanics Education and the Implications for Educators. *20th Annual Conference for the Australasian Association for Engineering Education, 6-9 December, Adelaide Australia.*

Hadgraft, R. (2007). It's time for a coordinated approach to computer-aided learning and assessment. *18th Annual Conference for the Australasian Association for Engineering Education, 2-5 December, Melbourne Australia*.

Hadgraft, R. (2009). Eng mechanics. Available from http://aaee-scholar.pbworks.com/Eng-mechanics [Accessed 29th January 2010]

Litzinger, T., Lee, S. H., Wise, J. C., & Felder, R. M. (2007). A Psychometric Study of the Index of Learning Styles. *Journal of Engineering Education, 96*(4).

Rezaei, A., Jawaharlal, M., Kim, K. J., & Shih, A. (2007). Development of a Hybrid Vector Statics Course to Reduce Failure Rate. *114th Annual American Society for Engineering Education Conference, 24-27 June, Honolulu USA.*

Steif, P., & Dollár, A. (2009). Study of Usage Patterns and Learning Gains in a Web-based Interactive Static Course. *Journal of Engineering Education, 98*(4).

Thomas, G., Henderson, A., & Goldfinch, T. (2009). The Influence of University Entry Scores on Performance in Engineering Mechanics. *20th Annual Conference for the Australasian Association for Engineering Education, 6-9 December, Adelaide Australia.*

Acknowledgements

Support for this work has been provided by the Australian Learning and Teaching Council Ltd, an initiative of the Australian Government Department of Education, Employment and Workplace Relations. The authors would also like to thank fellow project team members Prof. Timothy McCarthy, Dr. Anna Carew, Dr. Giles Thomas, Dr. Alan Henderson, Dr. Gangadhara Prusty, and project advisor A/Prof. Roger Hadgraft.