CHEMICAL ENGINEERING TRANSACTIONS, Volume 12, 2007
Edited by Jiri Klemeš

The Use of E-assessment in Chemical Engineering Education

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There have been many changes in approaches to teaching and learning in all education sectors in the last 5 years. In addition to the adoption of new methodologies, such as Enquiry Led Learning and Problem Based Learning, there has also been an adoption of new technologies, most especially those associated with the internet. The combination of methodologies and technologies have resulted in a general trend towards the increased use of student centred learning, in which students can learn at their own pace, and also make use of an increasing array of learning resources. Methods of delivery to university based students and distance based students have varied, although an adoption of one of the many virtual or managed learning environments or bespoke web based portals has started to become common place.

Less common, and also more problematic, is the use of e-assessment, both as a method of judging student progress towards learning outcomes, or as a learning tool. Assessments can be generally classed as formative, where students receive feedback from submitted work, or summative, traditionally in the form of written examinations. E-assessment is a generic term used to describe the use of technology in the assessment process. This paper describes how e-assessment has been introduced into the new first year programmes in Chemical Engineering. Methods of e-assessment have been evaluated and examples created. The most suitable method for early introduction has been selected, and integrated into the teaching and learning process through the WebCT virtual learning environment. The results of this pilot project are examined, and feedback from undergraduate learners discussed. Training methods in e-assessment for teaching staff are recommended.

1. Introduction

As we move further into the new millennium, many new factors are influencing the approach to teaching and learning in engineering disciplines (Perry, 2006, Cameron, Crosthwaite, Norton, Balliu, Tadé, Brennan, Shallcross. and Barton, 2007). Firstly there are new and changing demands from modern industry. Graduate engineers, most especially chemical engineers, are moving into more diverse industries than ever before. Although the knowledge and understanding they have gained from their studies have equipped them with skills suitable to a wider range of industries than was previously the case, demands from industry appear to be changing even more quickly, most especially in relation to skills involving practical problem solving, communications, IT skills, and some management and business skills. The ever increasing numbers of students wishing to participate in higher education, and the number of employed engineers wanting to update skills by participating in continuing professional development has led to pressure on the methods of delivery and learning styles employed. In addition, advances in technology, most especially those involving IT (hardware and software), have produced a generation of learners that have been exposed to highly sophisticated technologies and learning resources. There have also been rapid moves away from teacher led learning to student centred learning and the definition of learning outcomes to be achieved by students on programmes. Increasingly there have been benchmarks set down for structure and contents of engineering discipline areas, which have attempted to align these with industrial requirements and also learning skills for the future.

The increasing pressures on academic staff time from other areas such as research, administration, and student numbers, and from advances in technology and student aspirations, have led educational institutes to look closely at the methodologies used to train future generations of engineers. Consequently many academic disciplines, including engineering, have adopted new and emerging learning technologies and methodologies (Perry, 2002, Perry and Klemes, 2004). Increasingly e-Learning is being adopted by many educational disciplines, including engineering, as a means to achieve learning outcomes and provide a student centred learning environment. Changes in the technologies available, and methodologies adopted, has resulted in a critical evaluation of the traditional assessment methods that are generally used to judge learning outcomes. Consequently new types of assessment methods are being introduced into the curricula, including that of e-assessment.

2. Assessment, E-assessment and Learning

Assessment is an integral part of the learning system within the education sector. The form of assessments can be divided into two principal generic types, formative assessment and summative assessment. Formative assessment is concerned with the provision of developmental feedback to the learner from the tutor. The learner can gain from the feedback provided and adjust their learning style as appropriate. Formative assessment in chemical engineering is usually associated with laboratory reports and design projects. Summative assessmet is usually associated with the final evaluation of the learner's achievements, normally related to examinations. The Joint Information Systems Committee (JISC) defines e-assessment as "the end-to-end electronic assessment processes where ICT is used for the presentation of assessment activity, and the recording of responses (2007). The same report provides a number of case studies in e-assessment carried out at UK universities. Further examples in science and engineering are provided by Croft et al (2001) and Thelwall (2000).

3. Implementation of E-assessment in the Curriculum

The objectives of the first part of the project, as reported in this paper, were to evaluate the software chosen for the creation and delivery of the e-assessment, and to produce an initial e-assessment which could be used by students in the first year of their chemical engineering degree. The software chosen for the creation of the e-assessment questions was Respondus (v.3.5), and the e-assessment itself was to be delivered by WebCT 4. Respondus was chosen as the creation vehicle as the University of Manchester has a site licence and expert help is available at the university. The software has also been extensively tested for linkage with WebCT, the preferred virtual learning environment (VLE) for the university.

As this part of the project was principally concerned with the evaluation and early testing, it was decided to use a hybrid formative/summative approach. The e-assessment would provide a degree of feedback to the learners, but would also allow tutors (and learners) to gauge the progress towards the learning outcomes required. A number of chemical engineering test problems were implemented, a pilot e-assessment "Unit Systems" was developed and applied for student testing in October 2006, and feedback on the e-assessment from students and tutors was obtained and analysed.

Several types of questions were used in the initial test: Calculated, Multiple Choice, Multiple Response and Short Answer. Depending on the question type, the answer fields varied accordingly: checkbox, radio button or text (number) field. The feedback provided, in case of a wrong answer to the question, generally consists of a brief explanation (not a complete solution) with links to a Glossary, links to a Discussion Board, which provides another channel for learner-tutor and learner-student communication, and a complete solution on request to the tutor.

Typical chemical engineering course assessments require the preparation of a considerable number of problems and their solutions, and containing such items such as graphs and equations. Commonly tutors have their materials stored as MSWord files. Although WebCT and Respondus software are quite advanced tools for preparing tasks, we did encounter a number of problems in relation to the transfer of large amounts of data from .doc format files into these systems. The overall scheme of the data transfer process is given in Fig. 1.

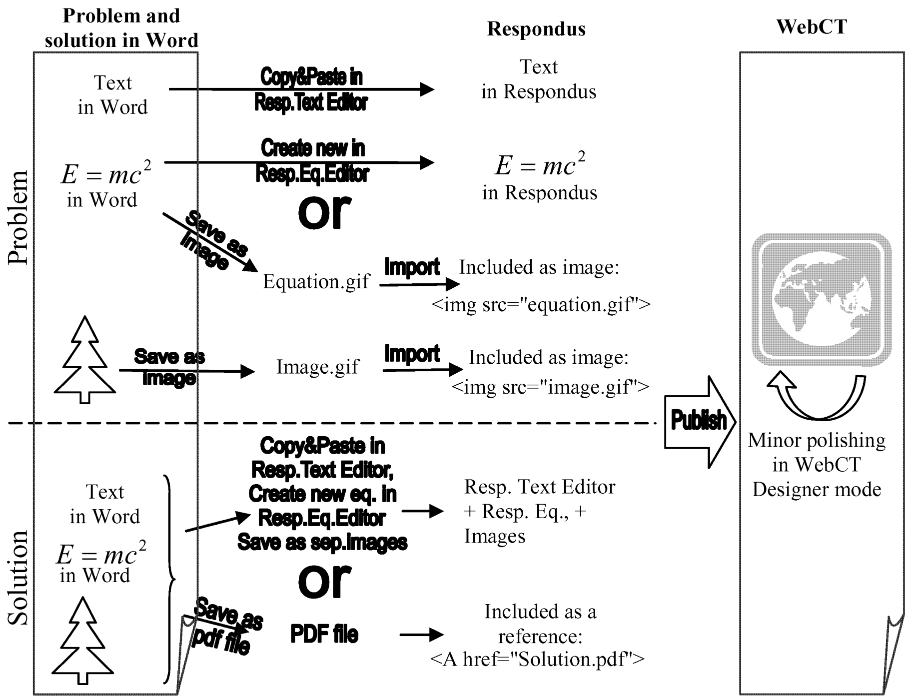


Fig. 1 Data transfer from .doc files into Respondus and consequently WebCT

Simple text transfer did not present problems, the process being accomplished by the copy and paste function. However, equations required to be retyped using the Respondus special equation editor. As chemical engineering courses require considerable numbers of equations this method can become prohibitively time consuming. We instead chose to process equations as images and to make reference to these in the Respondus and WebCT files. While this operation still takes some time, it is much less time consuming than re-typing equations in Respondus. Solutions can be handled in the same manner. However, in order to save tutors time, it was suggested that .doc files be converted into .pdf files and to include these as hyperlinks in the Feedback sections of the problems.

In order to ensure that the e-assessment process evaluates the learning outcomes routinely required in chemical engineering, specific attention had to be paid to calculation type questions. Although Respondus can handle this type of question, a considerable degree of re-working, of even simple questions, has to carried out to implement in the software. For example, the following format is required in the Respondus Editor for a Calculated question;

Question Wording:
A steel drum weighs (Mdr) {drummass} kg. Into this drum is poured (Vchem) {chemicalvolume} Imperial gallons of a chemical having a density <EQ_1> of {chemicaldensity} lbm ft^{-3}. What is the combined mass of the drum and chemical? Express the answer in lbm (with prercision of two decimal places).
Formula:
{drummass}(2.205/1)+{chemicalvolume}*(1/220)*(35.31/1)*{chemicaldensity}*

Variable Properties:

Name	***Min***	***Max***	***Precision***
drummass	*17.60*	*22.60*	*2*
chemicalvolume	*3.050*	*5.050*	*3*
chemicaldensity	*50.30*	*65.30*	*2*

Answer Properties:
Precision: 2 decimal places *Tolerance:1 unit*

Value/Answer Sets (up to 100):

drummass	***chemicalvolume***	***chemicaldensity***	***Answer***
22.38	*3.212*	*58.67*	*78.59*
19.00	*3.125*	*55.65*	*69.81*
17.80	*3.650*	*56.28*	*72.22*

It was also found that Respondus was only able to produce rather simple calculated questions, for example;

The heat flow rate through a wood board {L} cm thick for a temperature difference of {DT} ^{o}C between the two surfaces is {q} W/m^2. Calculate the thermal conductivity of the wood and type its unit name (15% of the score).
Formula:
0.01{L}*{q}/{DT}*

Multiple part calculations, such as the following, were not capable of being input into the Respondus software;

Calculate the intercept and gradient of a straight line.

In an attempt to avoid this shortcoming, two approaches were adopted. First we used a 'short answer' type question, comparing the number entered by the learner as text (to a specified precision) to the correct answer. The second option was to develop multiple response questions in which the solution will require several steps. Consider for example this problem.

Calculate the convection heat transfer coefficient for water flowing with a mean velocity of 2 m/s inside a smooth-walled circular pipe of inside diameter 5 cm. The inside wall of the pipe is maintained at a constant temperature of 100°C by steam condensing on the outside. At a location where the fluid flow is hydrodynamically and thermally developed, the bulk mean temperature of the water is 60°C. Calculate the convection heat transfer coefficient and the heat flow per unit length of pipe.

☒ a. Re = 210493
☐ b. Re = 270625
☐ c. Re = 189047
☐ d. Re = 583612
☐ e. Pr = 4.288
☐ f. Pr = 1.725
☐ g. Pr = 2.638
☒ h. Pr = 2.993

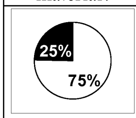
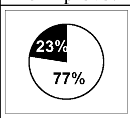
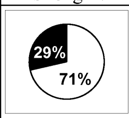
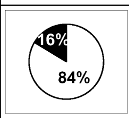
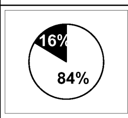
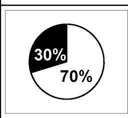
■ ■ ■

☐ u. Area per metre of pipe length = 0.4233 m^2
☐ v. Area per metre of pipe length = 0.0826 m^2
☒ w. Area per metre of pipe length = 0.1571 m^2
☒ x. Q = 62112 W per metre length of pipe
☐ y. Q = 42795 W per metre length of pipe
☐ z. Q = 81883 W per metre length of pipe

In the answer the learner has to select one answer in each of the sets: a - d, e - h, i - l, m - p, q - t, u - w, and x - z.

A pilot e-assessment was carried out and feedback from a questionnaire completed by tutors (involved in the unit) and students analysed. Overall 138 students took the e-assessment, many of them using computers outside of the university, the remaining using the university computer clusters. Table 1 provides feedback from some of the questions that were provided.

Table 1 Learners' feedback to the questionnaire (- Yes - No)

Did the e-assessment help you to understand better the material?	Did the e-assessment help you to determine the areas you need to improve?	Did the e-assessment help you to determine the areas of strength?	Did you find the feedback from the test useful?	Did you have enough time to complete the test?	Would you like to have more e-assessments in other topics?
					

Overall, the tutors comments were;

- That the test went very well.
- The test saved about a day's work in marking the test scripts (but since it took longer to set up than this, the saving will only accrue in future years).
- It was possible for the students to take the test from home, which many students did.

However, the delivery and completion of the e-assessment did reveal a number of small problems;

- One of the students was unable to log in to WebCT.
- One of the answers within the test was incorrect. WebCT did not allow to edit and re-grade the test after the students had taken it, so the tutor had to go through every submission.
- It was not possible to correct a couple of typing mistakes once the test had started.
- The types of questions available for calculations were limited.

4. Conclusions

It has been demonstrated that e-assessments can be carried out using easily available software. The pilot project has evaluated the potential of available software to format chemical engineering assessments into an on-line e-assessment form. Although complex equations are problematic, approaches have been devised so that these can be incorporated. Learner and tutor feedback has been extremely favourable, and it is envisaged that more use of this type of assessment will be made in future. The project is on-going, and further work is being carried out in formative e-assessments and the handling of complex calculation type questions. A training document is being prepared to assist tutors with the preparation of further assessments in the curricula.

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