INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
6 & 7 SEPTEMBER 2018, DYSON SCHOOL OF DESIGN ENGINEERING, IMPERIAL COLLEGE, LONDON, UNITED KINGDOM

AN E-ASSESSMENT FOR ENGINEERING DRAWING

Rod VALENTINE
University of Bath, UK

ABSTRACT
An effective method by which students learn the fundamentals of drawing practice is hand drawing part and general assembly engineering drawings. These drawings are then marked to assess the students' knowledge and understanding. However, when the student cohort size increases up to several hundreds, the time taken to mark the detail within a portfolio of drawings becomes significant too. Simply reducing the number of drawings would deprive students of learning how to draw a wider range of components and assemblies, so does not represent an ideal solution.
This paper discusses how an online assessment is used in conjunction with existing hand drawings to reduce the time taken to mark coursework. The online test comprises five different question types, such as, matching pairs, multiple-choice, and numerical, which are used to mark different aspects of drawing practice. The paper describes why these question types are used and how they can test for specific knowledge and understanding, which then need not be reassessed in the portfolio of hand drawings. Also discussed, is the importance of the portfolio of engineering drawings as an effective means for developing students' technical drawing skills.

Keywords: Technical drawing, online testing, undergraduate, engineering design

1 INTRODUCTION

This paper discusses the experience of using an online test or e-assessment as part of the engineering design teaching to the first year of a MEng degree. The MEng degree programmes are accredited by engineering institutions, such as, the IMechE, and therefore must adhere to the Output Standards of the UK-SPEC (UK Standard for Professional Engineering Competence), which is adopted by QAA (Quality Assurance Agency for Higher Education) as the subject benchmark statement for engineering [1]. Our teaching of engineering design within the Design unit should be mindful of "*Design at this level is the creation and development of an economically viable product, process or system to meet a defined need…Graduates will need the knowledge, understanding and skills to:*" meet the specific learning outcomes for Design, which is one of the five engineering-specific areas of learning an accredited degree must demonstrate. This paper focuses on the said three out of six terms of Interpretation, knowledge, understanding and skills, for Design when introducing students to drawing practice for the first time in semester one of the first year. Once students have this underpinning technical drawing ability, they, in semester two, design a product to meet a defined need.
The assessment strategy for the Design unit prior to the e-assessment was based entirely on coursework. Students would develop their drawing skills by creating engineering drawings of both individual parts and an assembly that together formed a portfolio. The portfolio is only one of the design assessments in the first year, but it is the main focus of this paper. The portfolio is an effective means of developing drawing skills because each drawing exercise is chosen to increase the technical breadth of student knowledge, and in so doing provides many areas of the drawing standard from which to assess and give specific feedback on. However, when the student cohort size increases up to several hundred, the time taken to mark the detail within a portfolio of drawings becomes significant too. The longer the time it takes to mark also means the longer it is before feedback can be given. This becomes undesirable because feedback is essential for student learning from knowing where to improve, and, if feedback is delayed, it deprives students the opportunity of applying their learning in the following exercise or assessment.

2 ASSESSMENT PLANNING

The objective of reducing the time taken to mark the portfolio of engineering drawings was not a simple case of just reducing the number of drawings. It was important to recognize that the majority of students have no drawing experience whatsoever, and therefore, an appropriate teaching strategy is to gradually step up their learning with several drawing exercises. To do this, the semester is planned to give students a new drawing exercise each week, so they can repeatedly practise applying their knowledge and deepening their understanding, but also broaden their technical ability with increasing difficulty of each consecutive drawing. Furthermore, by keeping a higher number of drawings comes the flexibility as educators to breakdown certain areas of the drawing standard [2], formerly BS308-1:1993, into smaller chunks of learning across several assessments making easier for students to digest.

2.1 Identifying e-Assessment areas

In order to identify which content of the Design unit is suitable for the e-assessment, a review of learning outcomes against the UK-SPECs 'interpretations' for Design. A sample of the first year Design unit's content is mapped against the 'interpretations' of skills, understanding and knowledge, and shown in table 1.

Table 1. Mapping learning outcomes against UK-SPEC's terms of Interpretation

Skills	Knowledge	Understanding
Create part drawings	Different types of dimension	How to dimension
Create general assemblies	Parts list & balloon referencing	How to construct geometry
Draw with different line weights	Feature representation: thread, spline, gear, etc.	Rules of drawing projection
Write clear annotations	Cross sections	Rules of sectioning
Calculate tolerances	Limits & fits, linear tolerances	How to use BS4500A

This initial mapping supports three decisions. Firstly, if the long-established process of students learning by completing a series of drawings is to change, then it is important to know where the different aspects in these drawings develop the terms of Interpretation and enable students to meet the learning outcomes of the Design unit? When the objective is to reduce marking time, it would easy to simply reduce the number of drawings, but this might leave unacceptable gaps in the grid in table 1 which shows how the Design unit's content maps across the terms of Interpretation. The second decision is on how the existing summative assessment should change from the format where detailed feedback is given on each and every engineering drawing? This style of feedback is valuable in the learning process because it pinpoints areas within the portfolio with specific information describing how each student can improve. Unfortunately, this comprehensive feedback at a detailed level in each drawing is very time-consuming for large cohorts. The third and final decision is to identify which drawing specifics are relatively time-consuming to mark and whether or not they could be tested instead by an e-assessment?

2.2 e-Assessment structure

The University's virtual learning environment (VLE) is Moodle. Within Moodle is an option to add a 'quiz', which is otherwise known as an online test, and within it are several types of question from which to build an online test. In table 2 are the question types used in the Design e-assessment and where they address (some of) the terms of Interpretation.

Table 2. Use of online questions types to test UK-SPEC's terms of Interpretation

		Knowledge	Understanding
Moodle question types	MCQ	X	
	Numerical		X
	Yes/No	X	
	Matching pair	(X)	X
	Single word	X	

Comparing both tables, a useful time saving option is in using the numerical question for marking tolerances. Two of the drawings in the portfolio require students to calculate tolerances from the Limits and Fits standard, BS4500A. A correct numerical answer in the e-assessment is only achieved if students understand how to interpret the alphanumeric reference and correctly calculate the upper and lower values. The answers in Moodle are set to recognize both upper and lower tolerance values, and the full upper and lower tolerance dimensions. The matching pair question type presents students with two lists of components, and then poses a question, which if understood, would give answers of correct pairs within the lists. However, before pairs can be formed, students need knowledge of the individual components to begin with, so this is why in table 2 there is a bracketed 'X' in the knowledge column also. Using a mixture of all these question types, the e-assessment is formed with fifty questions and students are given one hour to complete it.

2.3 Coursework structure

In order to achieve a reduction in marking time of the coursework, the submission format of it (i.e. portfolio of drawings) now needs to be changed. However, it is important to recall the benefits of the portfolio and, where possible, retain them. '*Portfolios have been widely accepted as assessment methods for decades in fields such as art, architecture and engineering…portfolios enable faculty to judge interim steps and draft products that were involved in the completion of the task or course of study*', [3]. Here, support is given to the wider amount of information generated by students in a portfolio and using web-based resources to preserve the content in the form of a digital portfolio. Suggestion is for the digital portfolio to be live, and for students to make annotations via electronic journals or reflections.

Whichever form the assessment takes, it must be able to measure how well students address the unit's outcome. Popper [in 4] supports portfolios as a means of assessing learning outcome achievement and, interestingly, also useful for diagnosing curriculum deficiencies that require improvement.

Clearly, a portfolio is an effective means of developing and capturing drawing skills within a Design course, so it was decided not to change the quantity or type of drawings. Automatically, the tutorial activity which supports the drawing exercises remains unchanged too. However, the change comes in how the assessment criteria are written. Rather than mark all of the drawings for accurate geometric representation, dimensions, sectioning, tolerancing, etc., it was decided to place one or two general learning outcomes on the early drawings and, in effect, mark them on whether the general outcome is met or not. The detailed marking comes in the final drawing, which, arguably, may be fairer as it gives those new to drawing time to familiarize themselves with the subject and not be penalized for errors of drawing detail in their early learning.

The new arrangement of learning outcomes across the portfolio begins with the first drawing being assessed for correct projection. There is detail in the geometry of each elevation, but this is for students to practise without penalty and quickly complete so that they are then ready for the next drawing. The second learning outcome against which drawings are assessed is correct projection and dimensioning. The outcomes throw a spot light on different areas of engineering drawing, another one of which is tolerancing, up to the final drawing where it is assessed fully. The early portfolio drawings are part drawings where students practice specific areas of technical drawing and the final drawing is an assembly. The distribution of marks changes from the existing portfolio where each drawing has an equal weighting to one where the final assembly drawing is 60% and the others carry an equal weighting of the remaining 40%. This broadly reflects the distribution of time spent marking the portfolio of drawings, where now the overall time is much reduced.

3 DISCUSSION

Introducing the e-assessment into first year Design unit has enabled the existing summative assessment of students completing a portfolio of drawings to be retained, whilst reducing the time it takes to mark. However, such introductions are not always well received, because online tests are strongly associated with multiple-choice questions and, as Scoulter [in 5] argues '*…they promote memorization and factual recall and do not encourage (or test for) high-level cognitive processes.*' The e-assessment here does comprise multiple-choice questions, and whilst recall may be sufficient for some other questions require more than recall, because they, for example, in testing students' understanding of 3rd angle projection require them to choose a specific elevation from several possible answers. This style of question is repeated with elevations of different components which reduce the likelihood of guessing correct answers. The e-assessment uses another type of question structure called numerical which requires students to perform a calculation and enter a number corresponding to, for example, an upper tolerance for a given nominal diameter. This kind of assessment tends to agree with other researchers, such as, Johnstone & Arnbusaidi [in 5]; believing higher cognitive levels of learning can be evaluated by MCQs because it depends on how the tests are constructed. The mapping of question types to the UK-SPEC's terms of Interpretation, shown in table 2, is useful in recognizing these two different views of how these assessments test for knowledge and or understanding.

The UK-SPEC's terms of Interpretation for Design also requires students to develop the skill of engineering drawing. This is supported by the (existing) coursework where they create a portfolio of drawings in which they should apply tolerances, create sections, and draw a range of dimensions in both part and assembly engineering drawing formats.

The main reason for using an e-assessment is the advantage of automatic marking. However, there are other advantages one of which is the ability to give feedback. The feedback in Moodle may vary from a single mark up to detailed explanations geared specifically to the answer. The test here is set to return just the overall result as a percentage, once it has calculated the different weightings set for each question reflecting approximately levels of difficulty. It might be that in the future the e-assessment is developed to include annotated feedback, but presently even the mark – revealed at the end of the test - gives some feedback on learning as well as a summative assessment to the cohort who would otherwise have to wait several weeks for the portfolio to be marked.

The Moodle software has many settings for the online test. A couple of settings used here are 'question bank' and 'overrides'. The 'question bank' is a store of questions from which the test is constructed. Furthermore, several banks may be created enabling questions to be grouped into categories, which is the structure of the e-assessment here, and shown in figure 1.

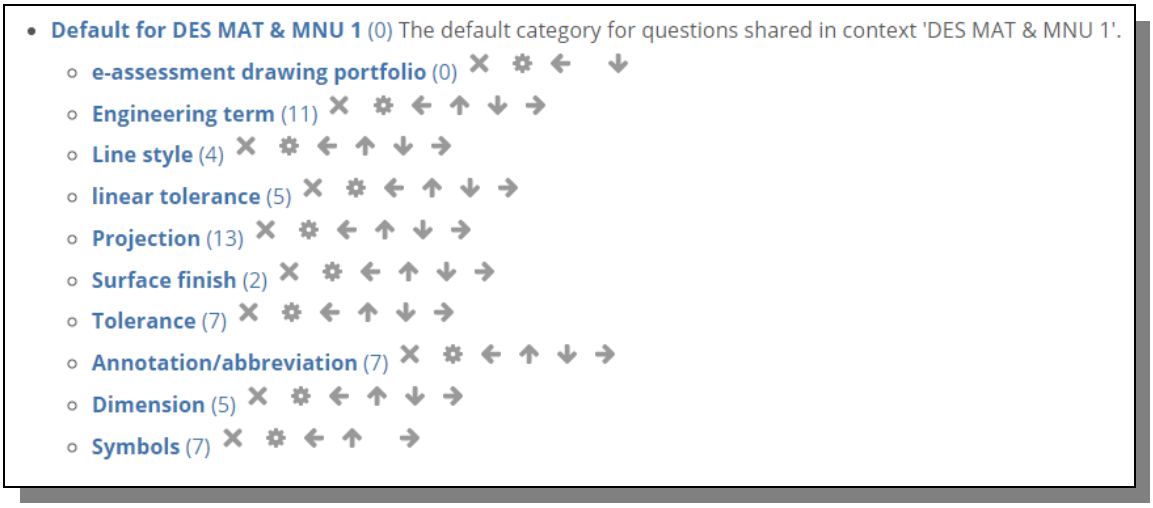

Figure 1. e-Assessment questions structured into banks

These banks of questions have two particularly useful functions. Firstly, it helps to quickly identify the areas of the unit's content being tested. And secondly, if the number of questions created in each bank is greater than that needed for the actual e-assessment, then it is possible to randomize the questions answered in between students. This helps to discourage blind plagiarism. The other setting, override, is useful for adjusting the time allowed for individual students. Students who are registered for

additional time in assessments can have their allowance pre-set within the Moodle software ensuring the summative assessment on a time basis is fair for all learners.
If there is a drawback or note of caution it would be in the time needed to create the online test. There is a learning curve with any new software, but particularly in knowing how to navigate around the many settings of the software, preparing illustrations within questions for a design context, and to thoroughly pre-test before going live.

4 CONCLUSIONS

This paper describes how an e-assessment has been created as a summative assessment within a Design unit on an accredited MEng degree. The learning of drawing practice within the first year Design unit is mapped against the UK_SPEC's terms of Interpretation, and used as a means for reflecting on how effective the e-assessment is in requiring more learning from students than just memory recall.
The motivation for the e-assessment was from the rise in cohort size and the associated increase in time to mark and give feedback on Design coursework. The restructuring of the coursework's assessment criteria and retention of the portfolio of drawings are explained to show how the marking time is reduced whilst preserving the opportunity for students to develop their skills for creating engineering drawings.
The e-assessment was created within the VLE, Moodle, and is shown to offer several useful features that include deterring plagiarism by various randomizing settings, and increasing fairness across student learning requirements by the use of 'over-rides' for automatically adjusting time allowances.

REFERENCES

[1] Engineering Council *The Accreditation of Higher Education Programmes*, UK Standard for Professional Engineering Competence, Third Edition, 2014.
[2] BS8888:2017 *Technical product documentation and specification.*
[3] Reeves T.C. *Alternative assessment approaches for online learning environments in higher education*, Journal Educational Computing Research, 2000, Vol. 23 (1) 101-111
[4] Buzzetto-More, N., Alade A.J., *Best Practices in e-Assessment*, Journal of Information Technology Education, 2006, Vol. 5
[5] Nicol, D., *E-assessment by design: using multiple-choice tests to good effect*, Journal of Further and Higher Education, 2007, Vol. 31 (1).