World Transactions on Engineering and Technology Education
Vol.5, No.2, 2006

Asking culturally neutral questions in engineering

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ABSTRACT: Assessment problems can arise in classes containing students from a variety of cultures with different experiences, attitudes and expectations of education, and often a very different range of relevant engineering experiences. It is possible inadvertently to set assessment questions or tasks that require responses of a type, which are unfamiliar or antipathetic to the student, and which utilise vocabulary that is not understood in a sufficiently sophisticated manner or else which implicitly require a set of experiences or knowledge that not every student possesses. There is very little literature on this topic relating to engineering students. In this article, the author cites several examples of culturally loaded questions and suggests that all engineering assessments should be scrutinised from the cultural perspective.

INTRODUCTION

Phil Race of the Higher Education Academy affirmed the following on of 23 December 2005:

> *Some academics … write exams in which part of the challenge is to work out what the question means before answering it. Too often academics applaud this approach for being* clever, *claiming that assessment is to sort out the sheep from the goats, and understanding the question's true meaning is part of that.* Nice one, *their colleagues say,* the clever ones will work it out. *But we do not include* cleverness *among the intended learning outcomes …*

As educators, we may not intend to write *clever* examination questions, but without sensitive scrutiny, some difficult-to-decode questions may slip through the net.

It is self-evident that all students are different. It is equally clear that, for every student in a cohort, the assessment associated with that module is the same. This is usually true for both the method(s) of assessment and for what is assessed. If, as is now regarded as good practice, the assessment is intended to verify the achievement of the intended learning outcomes, then it seems obvious that it must be the same for every student. This is surely required to ensure equity of treatment among students and between groups of students, and to establish confidence in the evidence provided by the assessment outcome (eg examination mark).

On the other hand, there is plenty of evidence (both academic and derived from common sense) for the difficulty of devising assessments that are totally free from bias towards or against one or more groups of students. There is a substantial literature relating to unintentional bias in assessment. Researchers have identified the potential for bias arising from cultural differences, gender difference, disability, as well as other factors [1-6].

BIAS IN ENGINEERING ASSESSMENT

Let a *neutral* assessment item (examination question or any other type of assessment) be defined as one in which every student has an equal opportunity to demonstrate the extent to which they have met the intended learning outcome (ILO) that is being tested. The item must, therefore, relate to an ILO that has been published to students in advance and it must be phrased so that the way in which the ILO should be demonstrated is clear to the student at the time of the assessment. In less pompous words, the question should be clearly understandable and relate to the appropriate curricular content. However, this is easier to write than to achieve.

There are a number of features of engineering education, at least in the UK, which either increase the difficulty of devising neutral assessment exercises or tend to disguise the presence of bias. Among these are as follows:

- A high percentage of students for whom English is not their first language. This can be as high as 50% in many classes. In many UK universities, the Faculty of Engineering contains the highest proportion of overseas students in the university;
- Many classes contain students from several quite different cultural backgrounds. For these purposes, there are significant cultural differences between students within Europe (Northern Europe versus Eastern Europe versus Mediterranean Europe for instance), as well as between the continents and sub-continents of Asia, America and Africa. Not least among the differences is the understanding of what an engineer is and does – the very word has no universality of meaning;

- A significant content of practical work in laboratories and on field trips;
- A large mathematical content, which can often mean that connected prose writing is not required in order to meet many of the ILOs;
- A professional milieu that demands clear reporting, both written and spoken, and a proportion of professional (as opposed to technical) materials, such as project management and business skills;
- The high cost of provision of a good engineering education, because of the need for laboratory space, equipment, materials costs and high staffing levels to ensure safety and practical skills training.

The net effect of these factors on assessment is that there will be items that are essentially numerical, mathematical, practical, oral and essay-based, but that no one of these forms dominates. These items will be attempted by students who have different English language skills, different understanding of engineering and different expectations of higher education, for which they may be paying an apparently high price. Therefore, it is quite easy for biased items to be hidden within this welter of assessment styles.

TYPES OF BIAS

Level of ILO

In higher education, one expects to assess ILOs at all six levels of Bloom's taxonomy – simply expressed as knowledge, comprehension, application, analysis, synthesis and evaluation [7]. However, these are merely the levels of cognitive skills based around knowledge. In a professional engineering education, one also expects to develop (and, therefore, must test) the affective and psychomotor domains, that is attitudes and practical skills. It is suggested here that educators nowadays rarely test practical skills, although our students are often exposed to practical experiences, yet their attitudes are almost never assessed. Elton, rather resignedly, reports the following:

> *The difficulty with designing attitude assessments is that in traditional forms of assessment, eg essays, it is almost impossible to distinguish a genuine attitude from a pretended report* [6].

However, he offers no alternative!

In the domain of cognitive assessment, which is in practice where most engineering assessment items remain, the first two levels of Bloom's taxonomy present relative few problems (but not none – see below). As educators, we can assess knowledge (level 1) by demanding the recall of information and comprehension (level 2) by asking for an explanation in the student's own words.

Even at this level, a cultural issue is encountered – it is deeply embedded in many (predominantly Eastern) cultures that there is no point in re-writing the words of a great master, because he/she has already expressed the ideas to perfection and it would be discourteous to paraphrase. Although many academics would have difficulty describing themselves as a great master, nonetheless this is how they may be viewed by some students. This issue can only be addressed by attempts to change attitudes prior to assessment, and is often tackled in the (unfortunately pejorative) context of plagiarism.

At level 3 and above (application, analysis, synthesis and evaluation), potential problems of bias abound. Words that might be utilised in assessment items could include analyse, categorise, compare, compose, contrast, create, criticise, critique, deconstruct, defend, demonstrate, design, devise, discriminate, distinguish, evaluate, generate, interpret, illustrate, justify, manipulate, modify, plan, predict, relate, reconstruct, relate and show. Each of these requires a sophisticated grasp of language, as well as the required cognitive understanding.

At levels 5 and 6 (synthesis and evaluation), a critical approach is essential and it would be impossible to demonstrate ILOs at these levels without using words and phrases that had come neither from lecturer nor book.

The above paragraphs have focused on answering the question. This is predicated on the writing of a clear question, which has two elements, namely:

- The use of a vocabulary that is understood;
- The use of contextual examples that can be interpreted on the basis of the student's prior experience.

An extreme example illustrates this latter point. Many universities in South Africa are now teaching engineering to a cohort of students, some of whom have grown up in townships without electricity. Following a course on materials selection, it would not be helpful to base an assessment on the reverse engineering of a 13 amp plug (which is an example used in many UK universities).

More subtle examples can be found when teaching management or business studies to engineers. A module on *Project Management* at the University of Liverpool in Liverpool, England, UK, is given to a large class drawn from every engineering discipline, computer studies and some pure sciences. In order to assess at level 3 (application of knowledge in a new situation), it is necessary to select a number of *new situations*, but to choose them in such a way that they are equally accessible to all the students. This rules out using excellent project scenarios based on dam-building (familiar to the civil engineers but to no-one else), or software engineering, or car manufacture, or banking or in fact almost anything!

A level 3 question, such as *devise a work breakdown structure for … (some familiar process)*, is very difficult to write in a neutral manner. What process is familiar enough to all students? No industrial process, certainly. One cannot assume that every student has, and has taken apart, a car, or even a bicycle. The unfortunate result is that the remaining scenarios are mundane, unexciting and tend to lack complexity – which is the key aspect that makes a task worth undertaking as a project. Domestic scenarios like *preparing a meal*, as well as being seen as trivial, are, in fact, not universal. Quite a number of students have never prepared a meal from raw ingredients, as becomes evident on reading their answers.

Similar issues arise from a question designed to allow students to be creative in the context of a SWOT analysis. The obvious question is *Analyse the Strengths, Weaknesses, Opportunities and Threats of the following proposition, and then make a recommendation whether it should be adopted.* It is very difficult to then identify a neutral proposition. Consider the proposition *let us build a fourth tunnel under the River Mersey for the use of pedestrians and cyclists*. However, many

University of Liverpool students, although aware of the existence of the road and rail tunnels, have never been through any of the existing tunnels, and do not understand how they were and are funded, so a proper analysis is not available to all students.

In an attempt to utilise only concepts known to everyone, the author used the real proposition (reported in *The Times* newspaper), *An advertising company should rent advertising space on students' foreheads*. This appears to be totally neutral: surely every student understands advertising and certainly every one has a forehead. However, upon reading 220 answers (some very imaginative), it became clear that a small minority (2 or 3%) of students did not understand the word *forehead*. This was clearly a failure of general (not technical) vocabulary, but it arose from the most thoughtful and well-meaning intentions.

Vocabulary

The vocabulary available to students is worthy of separate consideration. There have been many studies of the vocabulary skills of school students. One of the most relevant is by Farrell and Ventura, who looked at the technical and non-technical vocabularies available to 300 17-year old A-level physics students [8]. These are students from whom engineering undergraduates are drawn one or two years later. Farrell and Ventura measured both the claimed understanding and the actual understanding of 50 non-technical and 25 technical words, all taken from A level examination papers. Their results revealed some astonishing disparities, even among non-technical words.

It was found that 96% of the surveyed students claimed to understand *transmitted*, whereas only 30% could explain or define it. The equivalent results for *qualitative* were 66% and 29%; for *marked* they were 82% and 12% and for *significant* 91% and 46%. The situation was similar for technical words. For example *couple* scored 97% and 24%. The conclusion must be that we, as educators, cannot assume that the vocabulary used in assessment items can be universally understood, even when questions are couched in *ordinary* English. Particular misconceptions revealed by Farrell and Ventura included *qualitative* meaning *of fine quality* and *yield point*, which was defined as *the amount given out*.

The author's own experiences recently revealed first-year engineering students who did not understand *opaque* or *inflammable*. The vocabulary used in the last three years' examination papers on *Project Management* at the University of Liverpool included the following words, which were not defined in classes:

> *Assembly, auditor, balanced, batch, blizzard, chromium, client, construction industry, deadline, deliverable, finishing, functional, generalist, Human Resources Department, machining, morale, particulate, polishing, process, rapid prototyping, resource, revenue, review, sandwich, script, shooting (of film), stamping, standards, stock, trollies.*

It is not clear whether all of these were understood by all students, although their inclusion was intended to give appropriate contextual colour to otherwise dry questions. One recent e-mail from a student, just before the 2006 examination, gives a clear indication that this might be a problem:

> *dear_professor:*
>
> *While i was reviewing the past exams papers ,i found i didn't know the meaning of some words, which are not about the knowledge of this module but comes from the problem of my English level. Such as the "refurbishing your bathroom", i lost the meaning of it. to be honestly, my English is not good enough.*
>
> *in these cases, what can i do? can i ask the monitor teachers in the room for explaination?*
>
> *I hope it won't going to be considered cheatting or what's your suggestion?*

The reference to refurbishing a bathroom came from an earlier question, which asked for a *work breakdown structure* to be devised. The author had to devise an example of a project accessible to everyone, but this e-mail, and students' answers to the question, it revealed a failure on two levels: some students were unfamiliar with the word *refurbishment*, while others clearly had no idea what might be involved in refurbishing a bathroom. With the benefit of hindsight, further confusion could be expected if the student cohort contained Americans, for whom *bathroom* has a different and narrower meaning.

There are plenty more cultural and contextual differences of meaning for identical words. This section of the paper started with a discussion of the vocabulary skills of *school students*. In a recent question, it became clear that some students interpreted this to mean undergraduates at a university, while others took the intended meaning of secondary school students. Farrell and Ventura give a similar example with the word *primary* [8]. This is readily understood by A level students in the context of *primary school*, but not in the intended context *of primary importance*.

CONCLUSIONS

Under UK quality assurance procedures, examination papers, but not always other assessment items, are usually checked both by the setter and a moderator. If the assessment is not supposed to be a test of language skills, then it should be checked for technical accuracy, alignment to the ILOs and grammatical accuracy. This review indicates that moderators should also be asked to check for unintentional bias. It would not be easy to produce a comprehensive checklist for this purpose, but the issues and vocabulary discussed in this article could form a starting point.

Recent trends in engineering education may also help to mitigate the problem of cultural bias. Movements, such as the *Conceive – Design – Implement – Operate* (CDIO) Initiative and Active Learning in Engineering Education (ALE) network, promote active learning that makes it less likely that any student can remain culturally isolated [9][10]. Students who regularly work in teams, make engineered products and consider the engineering context of their studies will have a better chance of absorbing the local engineering (and wider societal) culture.

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