

Design of an objective assessment tool to evaluate students' basic electrical engineering skills: the OSTE



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Summary

This report discusses the developmental stage of a Higher Education Academy (HEA) – Engineering Subject Centre project which concerns the designing of an objective assessment tool to evaluate students' basic electrical engineering skills. The form of assessment is based on the principle of Objective Structured Clinical Examination (OSCE), which is an assessment method already widely adopted in healthcare education. Since it is being used in a different field, this form of OSCE has been named Objective Structured Technical Examination (OSTE). The approach used to develop the exercises included in the OSTE will be discussed.

This project will ultimately look at the effectiveness of this method of finding out the basic engineering abilities of a group of students and how it could be used to gear teaching towards any important or specific weaknesses that are discovered among the group.

Introduction

This paper reports the development of a new approach to the assessment of engineering students' skills, called the OSTE, in the School of Electronic, Communication and Electrical Engineering. OSTE stands for Objective Structured Technical Examination and it is derived from a well-developed assessment method used in a wide range of healthcare disciplines and called the OSCE (Objective Structured Clinical Examination). The key feature of this assessment method, unlike the assessed laboratory sessions or engineering projects to which students are often subjected, is that it provides a means of objectively measuring their individual performance and can relate to a very wide range of analytical and practical skills. It is often possible to give students the final mark on their performance at the end of the session and hence to reduce the marking burden of lecturers, but it does require the commitment of a large academic team to individually assess the students during the session.

Background

The initial idea for this project emerged from a research study funded by the British Heart Foundation and co-ordinated by one of the authors of the present article (G. Alinier 2003). That study was, at the time, jointly run by the departments of Nursing and Paramedic Sciences and of Electronic, Communication and Electrical Engineering. The study made use of Objective Structured Clinical Examination to test nursing students' skills prior to and after exposure to realistic scenario-based medical simulation training and compared the results of an experimental and a control group of students (Alinier et al 2004).

OSCEs were initially developed in the mid-seventies at the University of Dundee to assess the skills of trainee doctors (Harden et al 1975).

Since then, their potential has been widely recognised and they have been adapted to be used in most other healthcare-related disciplines, such as nursing (Ross et al 1988), radiography (Marshall & Harris 2000), dentistry (Mossey et al 2001) and physiotherapy with the Objective Structured Physical Examination (OSPE) (Hulett & Gilder 1986).

An Objective Structured Examination (OSE) is usually composed of a series of fifteen to twenty stations or exercises for each of which students have to perform a particular task within a given timeframe. Stations can either be theoretical, in which case the students would have to write answers to a specific question on a form, or practical, where the students would be observed and assessed performing a particular task or operating a piece of equipment. For the assessment to be objective, assessors should be provided with a marking sheet specifically designed for their station and which normally takes the form of checklists or rating marking scales. All stations should be numbered and allocated the same timeframe within which the exercise is to be performed or a question answered by students. If a particular station requires double the basic unit of time, it then needs to be duplicated, but only one student should be assigned to a double station at the start of the examination. Students rotate through these stations on an individual basis and in numerical order. It is preferable to use an automated software-based clock to synchronise the sequence of rotations through the stations. This is particularly useful if the examination needs to be carried out in more than one teaching laboratory. All stations should be signposted and a clear set of instructions should be printed for the students as well as for the assessor (when one is required to assess students' performance). All these points are well developed in the papers of Harden and Gleeson (1979), Harden (1990), and Alinier (2003).

Assessment is an important part of undergraduate studies in general as it is recognised that it significantly drives learning. Taking part in an OSE might oblige students to use pieces of equipment that they might otherwise avoid using, when working in groups, for example. It forces them to think and solve a problem without help from their peers. OSEs can be used as a formative or summative assessment tool. Before using any form of OSE, it is preferable to expose students to a mock examination session so that they understand and feel more prepared for the way the session runs. In general, when used as a formative assessment method, OSCEs prove to be very useful to students as well as to lecturers to determine learning needs (Townsend et al 2001, Alinier 2003) and it is expected that this would apply to all forms of OSE.

The rationale of this project was laid out in our grant application to the HEA – Engineering Subject Centre in the following manner: *'In industry, engineers are expected to be skilful employees. As a Higher Education (HE) institution claiming to train engineers, we have to ascertain that, upon qualification, our graduates are fully equipped and prepared to work as engineers. However, HE institutions are often failing to assess the basic engineering abilities of students on an individual basis. Students are very rarely, if at all, individually tested or assessed on practical engineering skills. For many years OSCEs have proved to be the gold standard examination of several healthcare-related disciplines. This is the perfect assessment tool to challenge a group of students on an individual basis over a series of varied short tasks related to their study area. Having some experience in the use and design of formative and summative OSCE for nursing and paramedic students we believe that it is a potentially beneficial assessment method for engineering students. We would like to explore*

the use of OSCEs with first-year electrical engineering students and ultimately present our findings to the engineering community through journal publications and conference presentations. This would demonstrate the feasibility and usefulness of OSTE, and this might encourage other institutions to implement our innovative idea.'

Aims and Objectives

As expressed in our rationale, this project aims to develop a new objective assessment tool to test the skills of engineering students based on the use of a series of short exercises carried out individually by students, as in an OSCE. We believe that the principles of OSCE can be adapted to meet the requirements of assessment, as well as of learning and teaching, in the field of engineering. For the purpose of this project we initially implemented this type of examination in order to assess the level of students' basic engineering skills at entry level. This involved developing a number of short exercises related to different aspects of electronic engineering. We have named this new implementation of the OSCE principle 'OSTE', which stands for 'Objective Structured Technical Examination'.

Through the involvement of lecturers from the School of Electronic, Communication and Electrical Engineering we have developed a series of different stations with tasks that can each be completed in about five minutes. This includes practical and theoretical exercises which address a wide range of electrical engineering skills. Explicit instructions for students, instructions for lecturers including the list of equipment required and also the answers, and objective marking sheets have been created for each station. A purpose-designed student feedback questionnaire, as well as a feedback questionnaire aimed at the OSTE assessors, have been designed in order

to evaluate the OSTE. The different components of the OSTE have been piloted with a group of fifteen second-year BEng students, resulting in a few changes.

For this project first-year BEng students were given the OSTE at the beginning of their first semester at University and again during their second semester. The results of the OSTE and of the feedback questionnaires allowed us to determine how the students have progressed, when it is more appropriate to ask them to take part in such examination sessions, how often they would like to be examined using this assessment method, and also whether their perception of OSTE changes over time. Similar feedback has been sought from the OSTE assessors.

Although the funding did not stretch to it, it would be interesting to test students' engineering skills throughout their courses by developing a greater range of exercises for second- and final-year students. The outcome of this mini-project will be disseminated widely in order to benefit the engineering community and hopefully encourage the use of such an assessment technique in other topic areas.

Methodology

The project was divided into four main stages. The first addressed the development of the OSTE stations and feedback questionnaires. In order to gather a wide variety of ideas about essential electrical engineering skills that could be tested as part of the OSTE, suggestions were requested from colleagues within the School, along with a call for ideas and an invitation to attend a seminar presentation about the project. Technical and academic staff responded with a range of potential exercises that were used to develop the OSTE.

The number of stations used in such an examination often depends on the number of students involved (Harden, 1990). Similarly, the number of lecturers that need to be present

during the session depends on the number of practical stations at which students need to be observed for assessment of their performance. In this project, which involved a class of twenty-seven first-year BEng electrical engineering students, sixteen stations have been developed and the OSTE session was repeated twice in order to assess the whole class. Although the number of stations could have been kept to a minimum of fourteen in our case, in order to maximise the reliability and validity of the assessment method, sixteen stations (Sloan et al, 1995) of five minutes each were developed.

A second seminar was organised in order to present the OSTE stations which had been developed along with their instructions, marking sheets and the feedback questionnaire. The aim of that seminar was to obtain feedback about each of the exercises as well as to present the project timetable, which included the pilot OSTE and the real OSTE sessions. As a result of colleagues' recommendations, the content of some stations was revised because the marking criteria were not judged to provide a strong basis for objective assessment. This seminar was also an opportunity for lecturers to express their interest in acting as assessor for a particular station.

In the second stage of the project the shortlisted exercises were piloted with a different group of students. This pilot OSTE was carried out with volunteer second-year BEng students as soon as the project was granted ethical approval. The pilot run enabled lecturers to familiarise themselves with the principle of such examination sessions, to make sure that the instructions and marking scales were clear and user-friendly and enabled objective judgement. It was also an opportunity to check that the tasks at the different stations could be completed by students in the allotted time. Further

refinements to the exercises and/or marking scales were still required at this stage. Depending on the average mark obtained for a given station of the pilot OSTE, the content of some of the stations was modified to make them easier or more challenging for the students. A brief analysis of the second-year students' performance (on average they scored 50.71% over the sixteen stations: see Table 2) showed that only the few stations for which they scored the lowest average marks had to be slightly simplified. This was done by providing a choice of possible answers for two

theoretical stations and by simplifying a circuit on a troubleshooting practical station. The feedback questionnaire was also used during the pilot OSTE and the results are reported in Tables 1 and 2. It shows that 100% of the students who took part in the pilot thought that the session was beneficial to them. 86.7% reported that the OSTE helped them develop their confidence in using the instruments they have at their disposal and that they would like to repeat the OSTE more regularly (Table 1), yet they only rated the session at 2.47 on a five-point Likert scale (1=very good,

Table 1: Feedback concerning the pilot OSTE

N=15 second-year BEng students	Yes	No	Missing
The OSTE session was beneficial?	100% (15)	0% (0)	0% (0)
Has the OSTE helped you develop confidence in using the instruments you have been exposed to?	86.7% (13)	13.3% (2)	0% (0)
OSTE should be incorporated in curriculum?	66.7% (10)	26.7% (4)	6.7% (1)
OSTE should be part of formal assessment of a module?	53.3% (8)	46.7% (7)	0% (0)
Would you like to repeat the OSTE more regularly?	86.7% (13)	13.3% (2)	0% (0)
Did you feel that on average the time allocation for the stations was appropriate?	46.7% (7)	53.3% (8)	0% (0)

Table 2: Results of pilot OSTE and feedback questionnaire

	Mean	Std deviation	
How would you rate the session? (1= very good, 5=very bad)	2.47 (15)	0.74	
How many times per year would it be useful to repeat the OSTE?	3.15 (13)	1.68	
What do you think would be the ideal balance between practical versus theoretical stations?	55.0% of practical stations (14)	10.00	Currently 43.75%
What should be their duration?	8.30 minutes (15)	4.31	Currently 6 minutes including assessment and feedback
Average score for pilot OSTE	50.71% (15)	12.15	

5=very bad). They would like to repeat the session about three times per year.

Following the pilot OSTE the period of time between each station was increased from one minute to two minutes to allow more time for the examiners to reset the exercise, and some marking sheets were modified to provide clearer indications of the expected answer.

The third stage of the project was the first 'live' implementation of the OSTE within the first semester of the first-year BEng programme. It took the form of a formative OSTE but without feedback provided to the students during the session, as would happen in a summative OSTE. This allowed us to determine the students' level of performance at the start of the course without preparing them too much for the time when they would repeat the OSTE at a later date. It was also an opportunity to evaluate the OSTE when run as a 'summative' assessment.

The fourth and last stage of the project was the second series of OSTEs during the second semester with the same group of students. It was run as a mixed-mode OSTE (Alinier, 2003) in order to allow collection of data related to students' performance as well as to provide them with feedback.

Upon completion of the project, a comparison of students' performance between the first and second OSTE was undertaken. Similar comparisons were made using the students' and assessors' feedback questionnaires. The difference in performance showed where skills have been acquired by students and which aspects of their knowledge need to be reinforced. Comparison of the students' OSTE performance could be made with the in-class assessment results to explore whether OSTE results reflect individual students' overall performance in their studies. This will also help us to determine whether or not OSTE should become part of our BEng curriculum, if it

is worth implementing with second- and final-year students, and if it could be used as a summative assessment method. At the time of writing 53.3% of the fifteen second-year BEng students would be in favour of using the OSTE as a summative assessment tool.

Conclusion

To our knowledge, OSCEs have never been adapted to suit any engineering-related areas. We believe that just as it proved beneficial in healthcare education, the development of OSTE will prove useful for the training and assessment of engineering students. OSTEs have the potential to be a very effective way of finding out the basic engineering abilities of a group of students. They could also be used to identify and address any important or particular weaknesses among the group of students before they qualify as engineers at the end of their studies. OSTE results could inform teaching so that some points are addressed with more or less emphasis according to how the students performed in particular areas.

It is worth noticing that the difficulty of the exercises can be adapted to the students' level so they can be used for first-year as well as final-year students. OSTEs could be used to assess students' electrical engineering skills through their university studies. Similarly, the subject of the exercises can be adapted to the students' discipline. Because we used the same method as used in traditional OSCEs, it was expected that students would appreciate the opportunity to practise important engineering skills through OSTE.

Many lecturers, especially with a non-healthcare background, are not familiar with the concept of OSCE and this HEA – Engineering Subject Centre mini-project is an ideal way to explore and disseminate its potential within the engineering community. Our adaptation of OSCE to an engineering context might

encourage other universities to adopt the same assessment method in their engineering programmes. Although the results are only based on a small pilot and have no statistical validity, it already gives an insight into the students' perception of such sessions.

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Biographical notes

Guillaume Alinier has worked on the development of the Hertfordshire Intensive Care and Emergency Simulation Centre (HICESC) for the past five years. He is a Senior Lecturer in Medical Simulation in the Faculty of Health and Human Sciences and has a background in Physics and Engineering. His work concentrates on developing and running short courses, assisting the teaching of colleagues, as well as enhancing and promoting the current simulation training tools. He has recently been appointed a University Fellow in Learning and Teaching.

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