The OSTE: Objective Structured Technical Examination for Engineering Students

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Abstract *— Objective Structured Clinical Examination (OSCE) has been widely adopted as an assessment tool in healthcare education. It normally consists of a series of exercises through which students rotate individually and are marked by an assessor. We conducted a study aimed at investigating whether or not the OSCE principle could be adopted in engineering education to assess students' skills. To our knowledge it is the first time that this principle has been applied in an engineering field. For this innovative application, this form of OSCE has been named Objective Structured Technical Examination (OSTE).*

A 16-station OSTE was developed by a team of University lecturers and technicians and piloted with a group of second year Bachelor of Engineering (BEng) in electronic and electrical engineering students to ensure that they had enough time to do the exercises and that the instructions and marking sheets were clear and enabled objective assessment. After a few modifications, the OSTE was repeated as a formative assessment with first year students during their first and second semesters. A total of 27 students and 11 assessors were involved in the different sessions. After each session students and lecturers were requested to fill a feedback questionnaire to evaluate the OSTE.

A total of 46 student feedback questionnaires and 33 assessor feedback questionnaires were collected. 93.5% of the students thought the formative OSTE session was beneficial to them and 73.9% reported it helped them develop their confidence in using the instruments they were exposed to. A clear majority of the OSTE assessors (93.1%) believed it should be incorporated into the first year BEng curriculum. On average lecturers and students thought this type of session should be repeated 2 and 3 times per year respectively. There were very mixed views from participants about using the OSTE as a summative assessment tool. 75.9% of assessors were in favour of summative OSTEs and 71.7% of students were against.

The results of this project show that assessors and students support the use of formative OSTEs in electronic and electrical engineering. We believe there is potential in the future for it to be also used for summative assessment as both students and lecturers become more familiar with the process. Although the OSTE exercises developed as part of this project related to a specific discipline, it could be applied to any other engineering field. The difficulty of the exercises can be adapted to the students' level so it can be used with first year undergraduate students through to postgraduate students. When used as a formative assessment tool, OSTE results can be used to identify students' weaknesses and appropriately inform the teaching

Index Terms *— Assessment of engineering skills, Objective Structured Technical Examination and Clinical Examination, OSTE and OSCE, Practical and theoretical test.*

INTRODUCTION

This article reports the development of a new approach to the assessment of electronic and electrical engineering students' skills, called the 'OSTE', in the School of Electronic, Communication and Electrical Engineering at the University of Hertfordshire, UK. 'OSTE' which stands for 'Objective Structured Technical Examination' is derived from a well developed assessment method used in a wide range of healthcare disciplines where it is referred to as the OSCE (Objective Structured Clinical Examination). It was originally developed in the mid-seventies in Dundee by Harden et al. to test junior doctors' patient assessment skills [1]. The key feature of this assessment method, contrarily to assessed laboratory sessions or group/individual projects to which engineering 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 of their performance at the end of the session, and hence to reduce the marking burden of lecturers, but it does however require the commitment of a large academic team to individually assess the students at the time of the session.

BACKGROUND

The initial idea of carrying out 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 [2]. This study was, at the time, jointly run by the departments of Nursing and Paramedic Sciences, and Electronic, Communication and Electrical Engineering. The study made use of OSCE to test nursing students' skills prior to and after exposure to scenario-based medical simulation training, and hence compare the results of an experimental and control group of students [3]. This method of assessment has been chosen because it can be adapted and this has been recognised by many healthcare disciplines such as nursing [4], physiotherapy [5], radiography [6], and dentistry [7].

OSCEs are normally composed of a series of 15 to 20 stations or exercises at which students have to perform a particular task within a given timeframe. Stations can either be theoretical, in which case students have to write answers to a specific question on a form, or practical, where students are observed and marked by an assessor performing a particular task or operating a piece of equipment. To make the assessment objective, all assessors are provided with a specific marking sheet corresponding to their station and which normally takes the form of checklists or rating marking scales with distinctive criteria. All stations are numbered, have a clear set of instructions, and students rotate through them individually and in numerical order. Usually the same amount of time is allocated for each station, unless the exercise of a station requires twice the amount of time imparted in which case that station needs to be duplicated. In that case only one student should be assigned to that station at the start of the examination. It is preferable to use a software-based clock to synchronise the sequence of rotations through the stations. This is particularly useful as the audio/video signal can be duplicated if the examination takes place in several adjacent laboratories or classrooms.

Assessment is an important part of undergraduate studies in general as it is recognised that it significantly drives learning. Taking part in such an examination might oblige students to use pieces of equipment that they might otherwise avoid using when working in groups for example. In a recent study on OSCEs, 86% of students reported that it helped them develop their confidence in using the equipment they were exposed to [2]. It forces them to think and solve a problem without help from their peers for example. One should notice that this type of examination can be used as a formative or summative assessment tool. Before using any form of Objective Structured Examination (OSE) for summative assessment, it is preferable to expose students to a mock session so they understand and feel more prepared to the way in which the session runs. In the case of the OSCE used as a formative assessment method, it proves to be very useful to students as well as lecturers to determine learning needs [8] [2]. Subsequently it is expected that this should apply to all disciplines and hence the OSTEs.

AIMS AND OBJECTIVES

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 thoroughly assess the basic engineering abilities of students. 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 could also be an appropriate assessment tool to individually challenge engineering students and evaluate their skills over a series of varied short tasks related to their study area. The aim of this study was to develop a new engineering objective assessment tool based on the OSCE principles, and to experiment its use with electronic and electrical engineering students. This involved developing a number of short exercises related to different aspects of electronic and electrical engineering. This new implementation of the OSCE principles was renamed 'OSTE', which stands for 'Objective Structured Technical Examination'. The main objectives were to demonstrate the feasibility and usefulness of the OSTE in engineering education, and to disseminate their use to other institutions if the implementation of this innovative idea proves to be beneficial.

METHOD

This project was divided in four main stages as described in the following paragraphs. The first stage of this mini-project addressed the development of the OSTE stations and of the feedback questionnaires. The number of stations used in such an examination often depends on the number of students involved [9]. Similarly the number of assessors required during the session depends on the number of practical stations on which students need to be observed for assessment of their performance. In order to gather a wide variety of ideas about essential practical and theoretical electronic and electrical engineering skills that could be tested in about 5 minutes, suggestions were requested from colleagues within the School. This was performed by addressing an email which presented the project along with a call for ideas and an invitation to attend a seminar presentation concerning the project. Technical and academic staff from the School responded with a range of potential exercises and from those, 16 were shortlisted during a second seminar to be used as part of the OSTE (Table 1). In the present project, which involved a class of 27 first year BEng electronic and electrical engineering students, the OSTE session was repeated twice in order to assess the whole group. Although the OSTE could have been

run twice with only 14 stations, in order to maximise the reliability and validity of the assessment method [10], the 16 stations were used. Explicit instructions for students detailing the exercise to be carried out, instructions for assessors including the list of equipment required with the answers, and objective marking sheets were created for each station. A purpose designed student feedback questionnaire, as well as a feedback questionnaire aimed at the assessors were designed to evaluate the OSTE at the end of each session.

The second stage of this project was to pilot the different components of the OSTE with a group of 15 volunteer second year BEng students and, based on the results and feedback, to implement a few changes to make some of the tasks easier and to correspondingly modify the marking sheets and instructions. The stations were arranged in the electronics teaching laboratories as illustrated on Figure 1. Prior to running the pilot session volunteer assessors received briefing about the station for which they expressed an interest to act as an assessor. This 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, user friendly, and enabled objective judgement, as well as to check that the tasks of the different stations could be addressed by students in the imparted time (5 minutes).

The third stage of the project was the first real implementation of the OSTE and took place during the first semester of first year BEng students. It took the form of a formative OSTE but without feedback provided to the students, 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 their second OSTE experience. The timing of the session was co-ordinated by a computerised clock set so that students had 5 minutes to perform the exercise of a station, followed by a one minute gap for them to go to the next station and for the assessors to reset their station. Students and assessors completed the feedback questionnaires to express what they thought of the session, how often they would like to repeat such sessions, and also to obtain some feedback about the OSTE when it is run as if it were a summative examination.

The fourth and last stage of the project was the second series of OSTEs during the second semester of the same group of first year students. It was run as a mixed mode OSTE in order to allow collection of data related to students' performance as well as to provide them with feedback [2]. To allow more time for the feedback, the rotation period was extended to 2 minutes between each station. Upon completion of the project, an analytical comparison of students' and assessors' feedback questionnaires was performed and is presented in the following section. The result will 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.

Station	Type	Station name
1	Theoretical	Colour coding of resistors
2	Theoretical	Conversion of gain from linear units to dB and plot on semi-log graph paper
3	Practical	Measurements of period, frequency and peak-to-peak voltage
4	Practical	Construction of electronic circuit on breadboard from a circuit diagram
5	Theoretical	Identification of frequency bands within the RF spectrum
6	Theoretical	Identification of good/bad solder joints, and determination of causes
7	Practical	Adjust oscilloscope settings to display properly an unknown signal
8	Practical	Soldering of components on a Veroboard
9	Theoretical	Identify different capacitor types and their typical use
10	Theoretical	Working out capacitor values
11	Practical	Drawing an electronic circuit using TINA
12	Practical	Set up function generator to output a 5kHz square wave with 20mV peak-to-peak voltage to the oscilloscope
13	Theoretical	Use of Karnaugh maps
14	Theoretical	Use of logic gates
15	Practical	Fault finding in an Op. Amp. Circuit
16	Theoretical	Operating an LED circuit using a logic gate

TABLE 1
LIST OF STATIONS DEVELOPED FOR THE OSTE

RESULTS

Both students and assessors having to complete a feedback questionnaire after each of their involvement in an OSTE session, a total of 46 student feedback questionnaires and 33 assessor feedback questionnaires were collected over the two rounds of OSTE sessions. The results of the questionnaires are presented in Table 2. It shows the results depending on the number of sessions that students and assessors have taken part in. According to the information collected from the questionnaires 18 students took part in both the first and second semester OSTEs, and 10 students only took part in one of the two series of OSTEs. The 11 assessors recruited were involved in two to five OSTE sessions but only completed a questionnaire at the end of a day in which they might have taken part in two contiguous OSTE sessions.

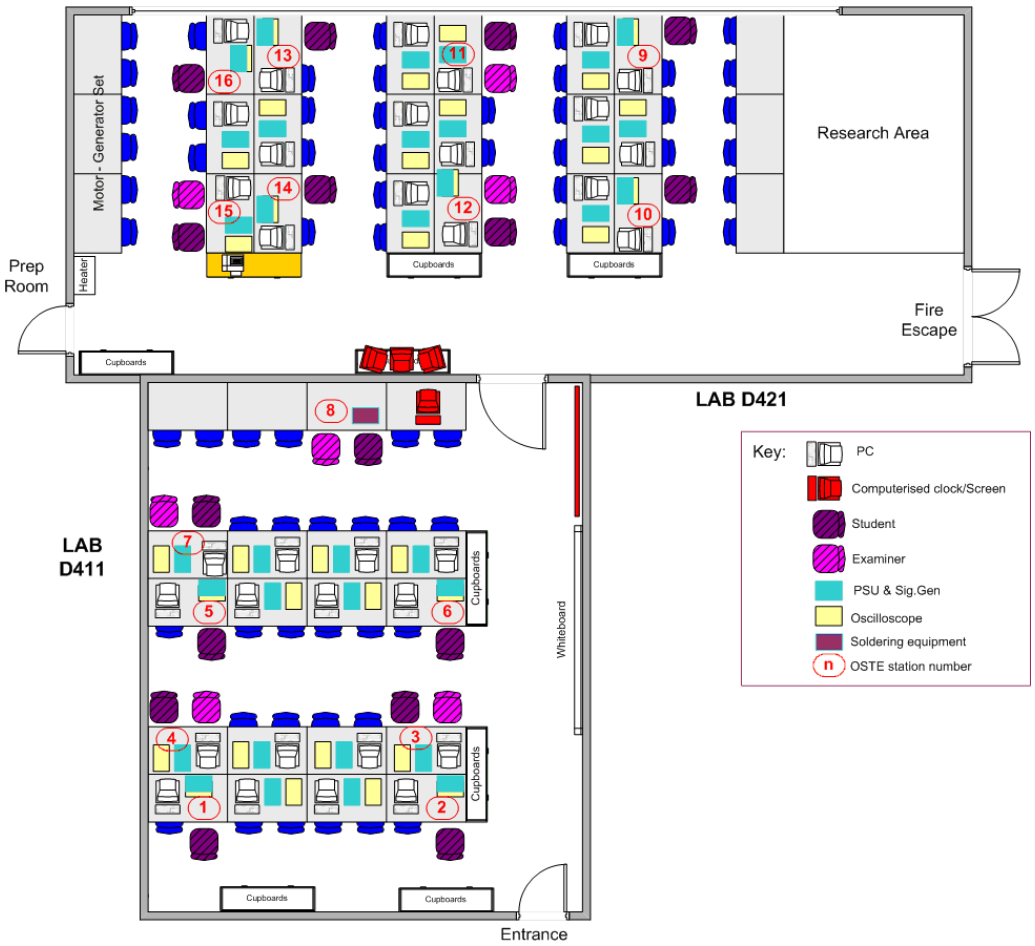
The results collected are very positive in general. For instance around 90% of the students and assessors thought the session was beneficial, which is perceived as a great success since it was the first time that such session was organised. After participation in their second session, 88.9% of the students reported that the OSTE helped them develop their

confidence in operating the instruments they were exposed to. When asked to rate the sessions on a 5-point Likert scale (1= Very good; 5=Very bad), 90.6% of the assessors rated them as very good or good, against 52.2% from the students.

Overall students would like to repeat such sessions 3 times per year, whereas assessors would only be prepared to do it approximately twice a year. This difference is probably due to the high level of organisation and time commitment required from the assessors on one part, and the fact that, generally, students like laboratory-based sessions. It seems that both students and assessors would prefer to see more practical stations (>54%) than they were actually exposed to in this OSTE (~44%). This however implies that more assessors would need to be present during the sessions.

In terms of adopting such sessions in the curriculum and using OSTEs as a summative assessment tool, assessors were more in favour than the students. 93.1% of assessors supported the adoption of OSTE in the curriculum, and only 53.5% of students shared the same view. On a more controversial point, 75.9% of assessors thought the OSTE should be used as a summative assessment tool, a view that is shared with only 28.3% of the first year students.

Concerning the timing of the stations, both students and assessors would have preferred a slightly longer period of time. It is evident from the results that with experience, the timing issue becomes less important as both students and assessors become more confident with the tasks required of them during each assessment period.



Many lecturers, especially as they were of a non-healthcare background, were not familiar with the concept of OSCE and were initially sceptic about this project. The seminars and briefing sessions were of major importance in order to convince enough staff to act as assessors during the OSTE. By the end of this project, the results show that the great of them were convinced of the potentials of using OSTEs in electronic and electrical engineering.

The results of the feedback from both students and assessors show that it has been positively perceived, even after the first session. Furthermore the results seem to show that increased experience of OSTE improves people appreciation of such sessions. Between the first and second sessions participants had the time to positively reflect about their experience. The noticeable difference between students and assessors regarding the use of OSTE as a summative assessment tool probably resides in the fact that students never like being assessed, whereas assessors probably value the objectivity of the OSTE. The time limitation given for each station is an important factor as it puts pressure on the students and can cause stress.

Although the current results are only based on a small pilot and have no real statistical validity, it already gives an insight of the students' and assessors' perceptions of such sessions. This project could have been extended by making a comparison of the students' OSTE performance with their in-class assessment results to explore whether OSTE results

reflect overall individual students' performance in their studies. This shows that further research in the use of OSTE is probably needed.

One may have noticed that although there were only 27 students in the cohort involved, 28 questionnaires were returned mentioning that it was their first OSCE experience. This is certainly due to an error from one of the students, but it can be assumed that it has probably not significantly affected the overall results of this study.

Questions	Sessions attended	Student questionnaires	Sessions attended	Assessor questionnaires
The OSTE session was beneficial?	1 (n=28) 2 (n=18) 1 & 2 (n=46)	Yes: 96.4% (27) Yes: 88.9% (16) Yes: 93.5% (43)	1 (n=11) Overall (n=33)	Yes: 90.9% (10) Yes: 87.9% (29)
The OSTE helped develop confidence in the instruments used?	1 (n=28) 2 (n=18) 1 & 2 (n=46)	Yes: 66.7% (18) (1 missing) Yes: 88.9% (16) Yes: 73.9% (34) (1 missing)	1 (n=11) Overall (n=33)	Yes: 63.6% (7) Yes: 75.8% (25)
How would you rate the session? (1=Very good; 5=Very bad)	1 (n=28) 2 (n=18) 1 & 2 (n=46)	2.46 ±0.2 - Good or very good: 46.4% (13) 2.28±0.2 - Good or very good: 61.1% (11) 2.39 ±1.0 - Good or very good: 52.2% (24)	1 (n=11) Overall (n=33)	1.70 ±0.8 (1 missing) Good or very good: 80.0% 1.47 ±0.7 (1 missing) Good or very good: 90.6%
Number of times the OSTE should be repeated per year?	1 (n=28) 2 (n=18) 1 & 2 (n=46)	2.79 ±0.3 2.83 ±0.4 2.80 ±1.4	1 (n=11) Overall (n=33)	2.09 ±0.8 2.16 ±0.8 (1 missing)
What is the ideal balance between practical and theoretical stations?	1 (n=28) 2 (n=18) 1 & 2 (n=46)	Practical: 54.58% ±3.1 / Theoretical: 45.42% ±3.1 (4 missing) Practical: 55.94% ±4.6 / Theoretical: 44.06% ±4.6 (2 missing) Practical: 55.13% ±16.2 / Theoretical: 44.87% ±16.2 (6 missing)	1 (n=11) Overall (n=33)	Practical: 56.11% ±10.4 Theoretical: 43.89% ±10.4 (2 missing) Practical: 54.50% ±9.1 Theoretical: 45.50% ±9.1 (3 missing)
The OSTE should be incorporated in the curriculum?	1 (n=28) 2 (n=18) 1 & 2 (n=46)	Yes: 64.0% (16) (3 missing) Yes: 38.9% (7) Yes: 53.5% (23) (3 missing)	1 (n=11) Overall (n=33)	Yes: 90.0% (9) (1 missing) Yes: 93.1% (27) (4 missing)
The OSTE should be used as a summative assessment tool?	1 (n=28) 2 (n=18) 1 & 2 (n=46)	Yes: 25.0% (7) Yes: 33.3% (6) Yes: 28.3% (13)	1 (n=11) Overall (n=33)	Yes: 90.0% (9) (1 missing) Yes: 75.9% (22) (4 missing)
What should be the duration of the OSTE stations? (minutes)	1 (n=28) 2 (n=18) 1 & 2 (n=46)	5.86 ±0.3 5.14±0.2 5.59 ±1.5	1 (n=11) Overall (n=33)	5.50 ±1.6 (1 missing) 5.16 ±0.9 (1 missing)

TABLE 2
DATA COLLECTED FROM THE STUDENT'S AND ASSESSOR'S FEEDBACK QUESTIONNAIRES

CONCLUSION

To our knowledge, it was the first time that OSCEs were being adapted to be used in an engineering discipline. We believe that in a similar way as it proved beneficial in healthcare education, the development of OSTE also proved useful for the training and assessment of engineering students. The feedback received demonstrates that the principles of OSCE can be successfully adapted to meet the requirements of assessment, learning and teaching in the field of engineering.

In this particular report we have not concentrated on the actual results obtained by the students on the individual OSTE stations. OSTE have the potential to be a very effective way of finding out the basic engineering abilities of a group of students, and 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 be taken into account to inform the teaching by addressing some points with more or less emphasis according to how the students performed in some particular areas.

Although such sessions can be very resource intensive in terms of staffing and equipment required depending on the type of stations developed, the assessors gave a very positive feedback that even demonstrated their willingness to adopt the OSTE in the course curriculum. A few students were so enthusiastic about the learning experience provided by the OSTE that they wanted to take part in more than just the 2 sessions to which they were invited. Our implementation of OSCE to an engineering context might encourage other universities to adopt the same assessment method in their engineering programmes.

It is also worth noticing that the difficulty of the exercises can be adapted to the students' level so it can be used for first year as well as final year students. Hence it could be used to assess students' engineering skills throughout their university curriculum. Similarly the subject of the exercises can be adapted to the students' discipline. It is in fact hoped that this project will promote the use of such an assessment method in other topic areas.

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