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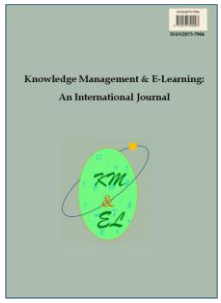

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Learning and assessment credibility: The design of examination strategies in a changing learning environment

Michael Diprose
Spectrum-tec Ltd., UK

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Learning and assessment credibility: The design of examination strategies in a changing learning environment

Michael Diprose, BSc (Hons), PhD, CEng, MIEE*

Spectrum-tec Ltd., UK
Spectrum-tec Ltd., 26, Brookfields, Calver, S32 3XB, UK
E-mail: Mike.diprose@spectrum-tec.co.uk

*Corresponding author

Abstract: Learning environments for higher education have changed considerably in the last 20 years, especially since the advent of the internet. In addition to the change in learning technologies has come an increasing politicisation of higher education and in the UK a change from being virtually free in the 1980s to one where annual costs (Sheffield Press Release, 2012) can now be in excess of £9000 p.a. Since there are various routes to attaining higher education and commercialisation and competition are being introduced, the output of the systems, i.e. a student's learning, is a factor which needs very careful attention and a moderating system is required, external to the educational providers, to ensure even quality. This should test a candidate's learning, not the educational process.

Academic skills are one measure of a candidate, but other qualities are often sought by employers, such as flexibility and breadth of learning to ensure that a company is able to respond to new market challenges and opportunities. Traditional examinations do not always test such skills.

It is suggested in this paper, that in order to accommodate the wide variety of routes to education, some candidates might register only for examinations at a university and not the course itself. In addition some ways of obtaining more information about a candidate's abilities are suggested.

Keywords: Assessment; Assessment strategies; Recruitment; Skills development; Examination design

Biographical notes: Michael Diprose was a member of the Department of Electronic and Electrical Engineering at the University of Sheffield, U.K. from 1976 until 2005. He left to start a company specialising in science and engineering communication in schools and developing electrical methods of weed control for agriculture and horticulture.

1. Introduction

For an economy or a company to develop, the ingenuity and flexibility of human resources are invaluable – especially as many innovations are now across disciplines. Identifying those people capable of thinking outside of 'the box' is crucial and now has a global dimension. Traditionally, higher education at universities has been seen as a source of developing talent – and still will be for some time to come - but the advent of new technologies, especially the internet, has meant that a good education is not now exclusively provided by the university sector.

With all the various ways now possible of receiving a higher education or training programme and the global nature of business and employment, assessing a candidate has to become more than accepting a degree certificate. The value of that certificate must be known to the prospective employer. Since it is almost impossible now to verify or accredit all sources of education and training, the focus should be on the output of that education or training system – the candidate. In addition, it is not just their knowledge that needs to be identified, but the ability and confidence to use that knowledge. Given the new situation, new assessment methods should be found, rather than continue to rely on traditional examinations, which favour the academic ability of a candidate and do not necessarily examine and assess a candidate's ability to use knowledge or interact with others in problem solving.

This paper suggests ways of examining candidates which involve giving clues to questions, allowing discussion between candidates and offering methods rather than solutions and also an independent verification system that focuses on the candidate and not the educational process and paperwork.

2. Discussion

In the 1990s, with the advent of the internet, the possibilities of using it for higher education were discussed. Some enthusiasts of e-learning, predicted the end of universities, proclaiming that all learning would be done over the web (Mcleod, 2000; Blunkett, 2000; Goddard, 2000; Grove, 2012). This has not happened and it seems that the traditional universities are as popular as ever and believe they will remain so (Noble, 1997, 1998a, 1998b; The Report of a 1998/1999 University of Illinois Faculty Seminar, 1999). The University of Sheffield, UK, for example has recently announced an £81m investment in new engineering teaching facilities for an extra 1500 students. This demonstrates a great deal of confidence in its future (Sheffield Press Release, 2012).

Distance learning has been available for decades initially through the postal system and towards the end of last century via the radio and television. The Open University in the UK is a very well respected institution, offering degree level tuition to people often in full time employment.

The advent of the web and a rise in interest in higher education globally offered opportunities for traditional universities to expand their student bases and a variety of ideas and schemes were tried (Novell, Bohigas, & Jaen, 2006). The author and colleagues were involved in looking at the possibilities of distance learning through innovative technologies and started by examining just what was involved in teaching at undergraduate level and what would be required in terms of online material to replace lecture courses.

The processes involved in educating undergraduates to a high standard are complex and usually require an established infrastructure – hence the survival of universities, in spite of repeated claims that the web will make them unnecessary. Fig. 1, Fig. 2, and Fig. 3 are examples of those drawn up at the time to investigate how engineering students might be taught with the new technologies (Diercks-O'Brien, 2002). Fig. 1 (Diprose & Syder, 2004) illustrates a pedagogical learning flow. Both knowledge and the confidence and ability to use that knowledge need to be imparted to students. Low achievers generally have little knowledge and no confidence, whilst high achievers usually have an abundance of both. Higher education needs to move undergraduates from the origin areas when they first start a course, to the top right hand corner by the time

they leave, by one route B or another. Simply imparting knowledge, i.e. going along path A is not enough.

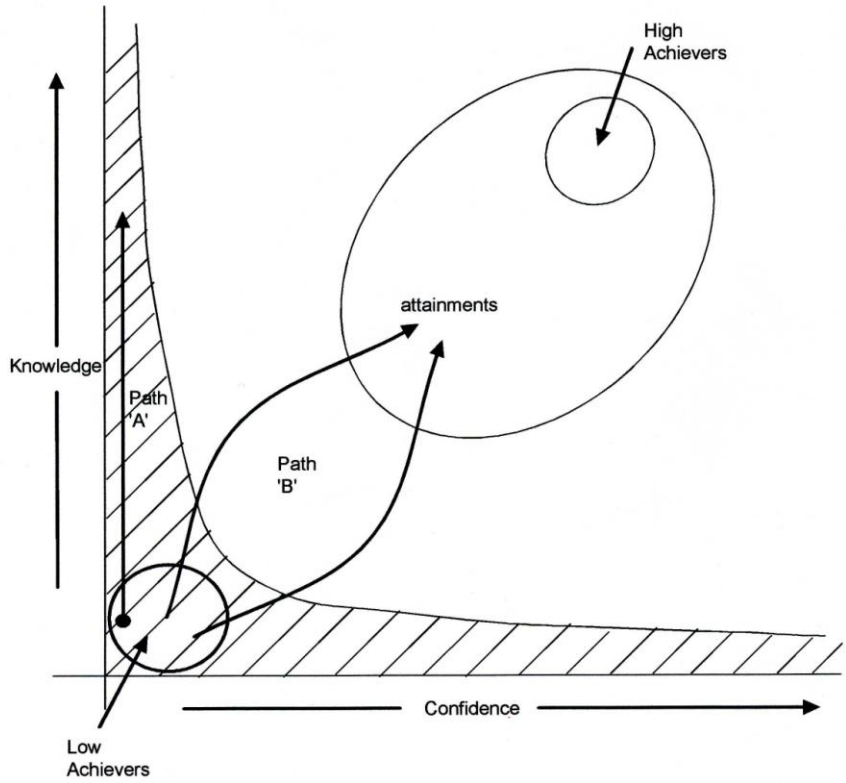

Fig. 1. An academic education should take a student from the bottom left hand corner (entry) to as far as they are able to get towards the top right hand corner

Fig.2 (M. F. Diprose & M. Robertson, personal communications, 1998) shows that many factors are involved in educating an undergraduate. Inputs to a student's learning include the promotion of self assessment and interaction with other students and the building of confidence of a student through recognising their attainments. Technical skills are vital and individual support is necessary to a greater or lesser extent, depending on the student. Their needs and attainments are outputs and these need to be assessed and used for feedback to continue the education process.

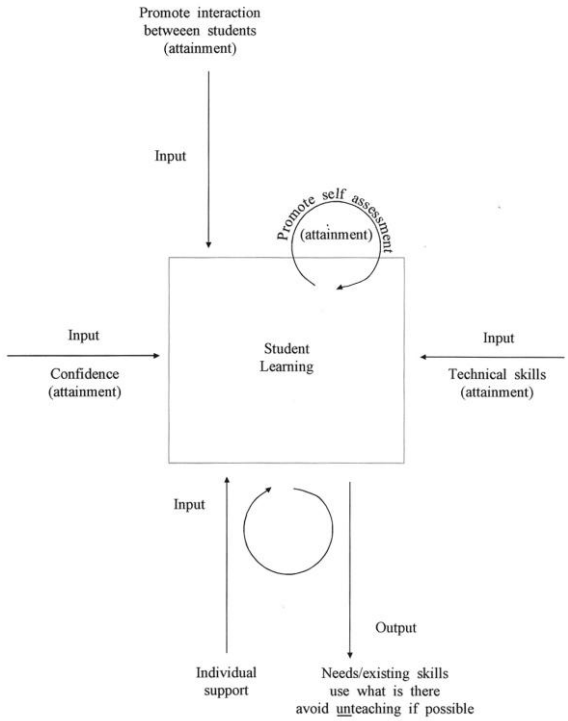

Fig. 2. A consideration of factors involved in student learning in higher education

Fig. 3 is one describing what would be involved in replacing lecture courses with e-learning. Someone has to have overall responsibility for the course content, production and delivery. There needs to be an academic input to the script, with well defined learning outcomes and a production facility generating the course, including any TV, video, audio, graphics, animation, photographs etc. These all have to be programmed to produce the electronic material into a usable product online. Then, if it is to be a part of a degree course, means of assessment must be defined and the course administered and maintained. Good online teaching and learning is no trivial matter and requires considerable resources and commitment to succeed.

Undergraduate education has traditionally been offered at a fixed geographical location with all the resources, teaching staff and facilities and administration both academic and pastoral available on that site. Distance learning enabled the teaching of a diffuse student base e.g. the Open University (OU), although the OU did provide all the teaching material and summer schools.

The web, modern technology and the demand for education globally has meant, however, that there are now more routes possible to higher education than before. Learning from a distance and from a variety of sources is possible. Fig. 4 (Diprose, 2012) shows how a student might be able to obtain tuition from all sorts of sources – the internet, local libraries, a local university library, borrowed notes from friends and colleagues. All these possibilities constitute learning elements dLe. In addition, personal help and tuition could be obtained from local sources such as retired teachers or academics, postgraduates or friends. All these constitute further learning elements dLe.

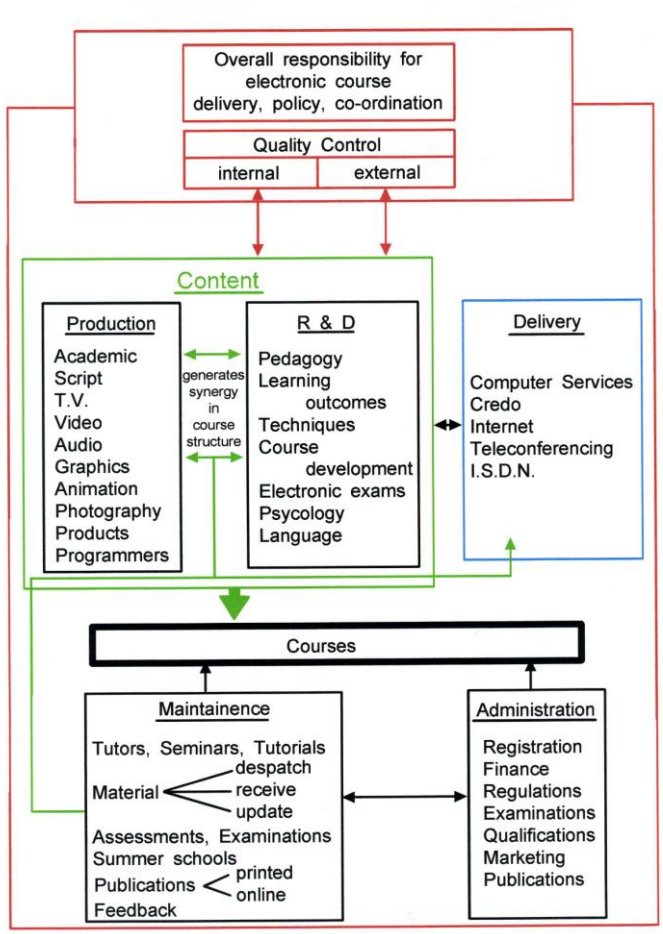

Fig. 3. A consideration of the factors involved in providing high quality e-learning material to replace lecture courses in higher education

If we look at this diffuse learning system and apply a learning law (modelled on Ampere's Law for magnetic fields) by saying

$$\oint L.dle \geq EXn \text{ goto } EXn+1$$

Path independent

If all the learning experiences L from learning elements dLe, around any path are summed and the sum is greater than necessary to pass an nth examination EXn, then the candidate can proceed to the next part of the course and eventually to the n+1th examination e.g. Fig. 4.

Although this learning law is in the context of an engineering degree, it is applicable across all disciplines e.g. the arts and sciences as well as engineering.

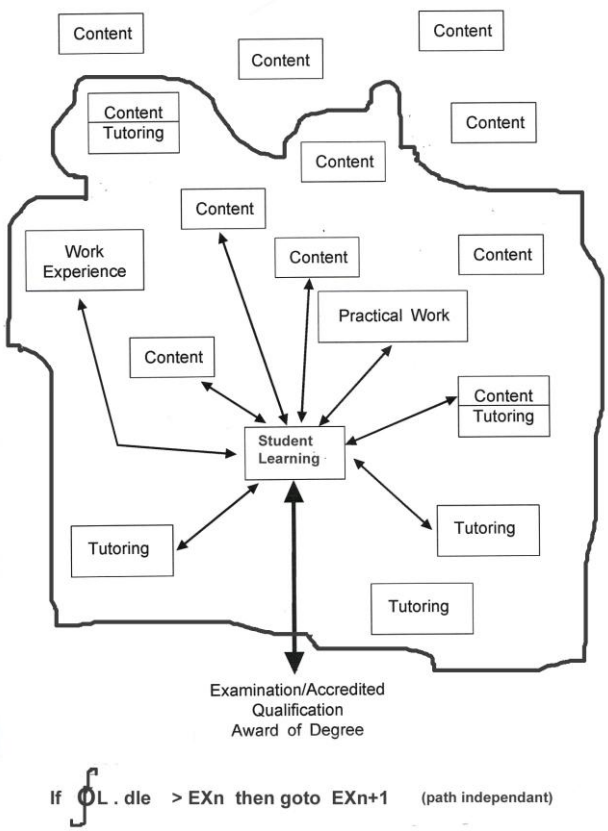

Fig. 4. One of the very many possible paths enclosing learning elements that a student might choose during their self directed study

This is, in essence, what happens at all universities, where candidates are allowed to pass to the next year of a course if they pass their examinations. In these cases, the paths of study and learning outcomes L.dLe are prescribed by the university, but if an independent candidate chooses and follows their own path (as in the example of Fig. 4), enclosing as many or as few learning elements as they choose and they are able to pass the requisite examination(s) at the required standard, why should they not be able to proceed through a course and receive the appropriate qualification?

This means, for example, that if a student cannot attend a full time course at a university for personal or cost reasons, they can still obtain a recognised qualification, if they could register for examinations only at a recognised university.

A system might evolve where a candidate registers for examinations only and pays a reduced fee e.g. 10 or 20% of the full fee. They receive details of the courses, sample exam papers and tutorial papers, but no tuition or feedback. An annual renewal fee could be charged to allow for informing about any changes of course, for example. The candidate must arrange for all their own tuition and not be eligible to attend classes. When they think they are ready they present themselves for examination at the institution. If they pass they are allowed to proceed to the next stage; if they fail they must continue studying and pay another examination fee.

Such a system might allow all the benefits of the opportunities offered by the modern technologies and the internet to be open to a global market, offering high quality qualifications from recognised institutions at cost levels much lower than those of full time attendance to students whose circumstances prevent them from full time study. In addition, given the near impossibility of accrediting all routes to higher education, if a relatively few providers could be rigorously accredited, so that their awards were internationally recognised, then more graduates could be provided than the full time, attended course would allow.

The globalisation of both education and employment and with all the routes to higher education that are arising, along with the growing pressures in some university sectors, mean that a way of assessing candidates and their qualifications, by employers, is becoming more important.

Prior to the 1990s, in the UK, universities were usually self determining. The academic staff in the various departments decided admissions, curriculum content, teaching methods, examination practice, and set their own standards. These were overseen by examining boards within each university and related to other universities through the use of external examiners.. Departments were self governing to a great extent, and since they were proud of their reputation, this kept standards high by self–regulation.

Then a change occurred – certainly in the UK – as governments realised that knowledge economies were the future, not just manufacturing economies. Since knowledge is stored (e.g. libraries), taught (undergraduate and postgraduate) and generated (research) within universities, they became important and government decided to intervene and so higher education became politicised. The UK Government started a process of generating university governance by management, through the Research Assessment Exercise (RAE), the Teaching Quality Assessment (TQA) and various initiatives on admissions (widening participation) and fall-out rates (minimise).

Universities were given quotas for admissions, then targets for students from state schools and disadvantaged backgrounds. If drop-out rates were too high there were penalties. The UK has a commissioner for access who examines intake for all universities to make sure state school pupils are in sufficient numbers compared with those from private schools. Too few and fee levels can be compulsorily reduced.

In the UK student fees are now around 10,000 Euros per annum, plus the cost of living, books, leisure etc. Higher education has become expensive and students need to choose their courses and resultant outcomes carefully. To assist choice, there are published various sets of 'league tables' comparing universities and courses, for prospective candidates to study, so competition has been introduced between the different universities (The Guardian, 2013; Times Higher Education, 2013). UK higher education is becoming a market led system.

Pressures on and between universities are rising from competition, commercialisation, regulation and legislation.

Given that a degree course in the UK may now cost a candidate 30,000 – 50,000 Euros, it is imperative that the education and qualifications that undergraduates receive are value for money and not only valued by the graduate, but by external observers as well.

After all, what is the purpose of all this education? An education in itself is valuable, but mostly it is for a qualification: and not just for the certificate, but for the opportunities that the certificate will bring. So, it needs to be recognised and valued by

others than the student. An employer must be certain that the qualification awarded represents the graduates learning and ability and that it is of a high standard. The award must have a recognisable integrity and given the growing globalisation of education and employment, that integrity should be internationally recognised.

Traditionally, the confidence has been in an institution's reputation, but with the advent of all the new routes to higher education, the movement of potential employees across continents and a competitive sector, how can a qualification be verified? At present if there are 100 departments awarding engineering degrees, for example, it is reasonable to suggest there are 100 different ways of assessing students and 100 sets of standards. These will fall into broad groups and the external marker system brought a level of equality into the traditional system, but in view of all the variations between universities, all of the routes to higher education and all the developing pressures, then a single set of standards, against which the others can be compared, is going to be required in the future.

The extensive Teaching Quality Assessment exercise carried out in British universities in the late 1990s to around 2003, was an attempt to do this, but it has not been continued (Laughton, 2003) as it was an extremely time consuming exercise and concentrated on an assessment of the paperwork. The author can remember a room full of tables covered in stacks of documents. During the several days of assessment only one of his lectures was observed (the same for all his colleagues), although the panel did interview a selection of undergraduates from all years.

If one wants to test the system, it is no good examining the paperwork or what the mechanism provider says is happening; the true output must be measured – that is the student's learning and development of critical, analytical and investigative skills. The process can be assessed, as this indicates what the output is likely to be, but it should not be the focus of the exercise.

The author suggests that an independent method of assessing students learning should be available to employers, professional bodies and anyone else who depends upon the credibility of an award. Verifying bodies could be established to set up verification examinations for students (or departments) to take, the design of which could disclose more information about a student's abilities than just a % mark or class of award. (e.g. comparing spread of marks, clues used, types of questions tackled). For example, there could be an Examination Verification Evaluation (EVE) process. This would be in the form of an examination or series of examinations that candidates undertook and not an evaluation of their educational process. It could be easier for a verifying body to produce a single set of standards against which candidates (individual or departmental) are judged on their outputs, than try to equate and compare many various educational processes.

For electronic and electrical engineering degrees, provision of EVE systems could be by commercial companies as there is no reason why a fee should not be charged for the EVE award. A combination of professional bodies to decide on the standards and independent companies to administer them would be a strong contender for EVE, providing a service to industry in verifying the students emerging from the variety of degree courses and higher education provision routes, and it will be paid for by the candidates. It is important, however, that the independence and integrity of the verifying body be transparent. There cannot be any conflict of commercial interest. A verifying body, for example, should not be providing educational content. There is a strong case for small, independent companies or individual consultants to administer the verification process, rather than a multi-national group, whose commercial activities may be very broad.

A control system processes a set of inputs, to produce a set of required outputs. In order to decide if the control system is working it is usual to measure the outputs and, if necessary, provide feedback to alter the control system or inputs to produce the specified output. It is not acceptable to measure the inputs and the control system function and assume that the outputs are, therefore, correct. Given the wide variety of entrance standards and qualifications and the variables in the education process between universities and countries, it makes sense to have a system that measures the outputs against a common standard, rather than try to standardise higher educational systems. Universities can continue to award degrees in their own way and have whatever admissions policies they choose or have imposed upon them. The output is the important factor and that is in the quality of their graduates.

The verification procedure could be for individual students or departments. For the latter a department could seek an EVE assessment. To achieve this, its students would be required to sit an examination or series of examinations brought in by the EVE assessors and taken away and marked by them. The results are then fed back to the department and, if satisfactory, an EVE accreditation awarded (e.g. Fig. 5). This minimises the work load on a department as the process does not require any paperwork preparation, or indeed any preparation apart from organising the students and a place for them to be examined under EVE procedures. It is the verifier who must provide the examinations to the required standard and mark them. The dark, solid line A represents the spread of marks from a departments exam results. If the EVE results were given by the dotted line (B) then they would be in reasonable agreement, but if they were more in line with the thinner solid line (C), they would not qualify for an EVE award.

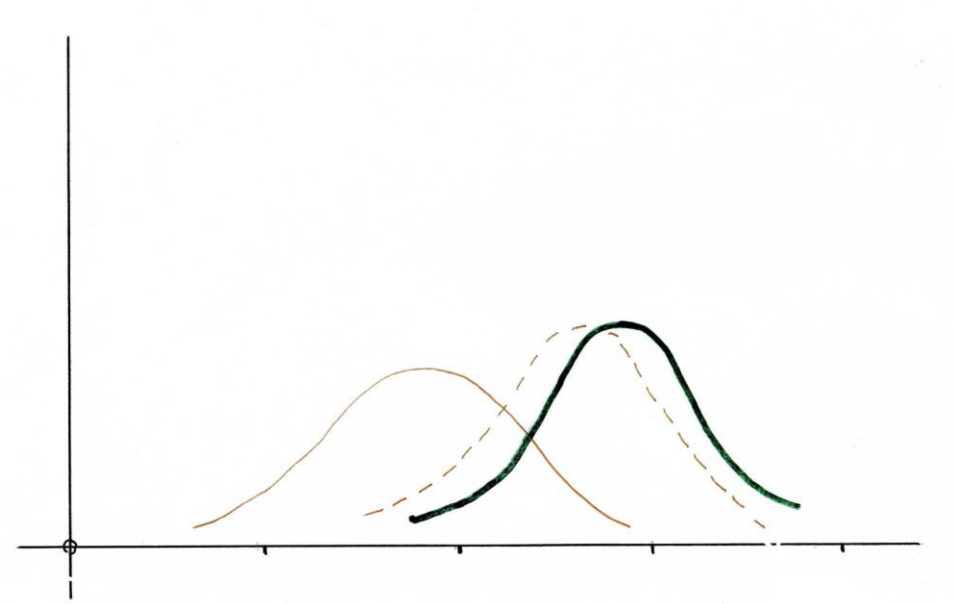

Fig. 5. A representative diagram of how an EVE assessment of a department's results might appear. Solid line A represents departmental results, dotted line B and thin line C represent two possible sets of EVE results

A traditional (UK) examination of two or three hours per paper, with the student working quite independently and from memory, does not reflect the normal conditions under which employees will work. They will not (usually) be placed in an empty office to

solve a problem, alone, with instructions to emerge after two or three hours with solutions. Problem solving involves use of resources including colleagues and access to information. An EVE assessment of students, therefore, might include the opportunity to see how they interact with others and how they are able to gather and organise information to solve problems.

Consider the following proposal for a series of assessments to gain as much information as possible about a candidate:

10.00 – 12.00	standard exam (with clues)
12.00 – 13.00	lunch
13.00 – 14.00	open book exam
14.00 – 14.30	tea (allowing discussion of questions between candidates)
14.30 – 15.30	re-visit second exam if candidate wishes
15.30 – 16.00	tea
16.00 – 17.30	multimedia assessment – tutorial + questions

The series could be over one day or the lunch and tea breaks could become overnight breaks or one or more day breaks.

The standard exam could have 4 standard bookwork questions and 4 thoughtful ones - all with clues for those students who were not so quick off the mark. Sometimes an able student just cannot see how to start a problem. To overcome this and to see how they respond to help, they could ask for clues. This is analogous to asking a colleague, for example.

A Standard Question:

Derive an expression for the received power Prec at the antenna of a radar system whose transmitted power is Pt, from a target at range R in terms of the characteristics of the antenna (Hall, Garland-Collins, Picton, & Lee, 1991).

This is a standard type of question, which those with good memories can sail through to get to an answer such as:

$$\mathrm{Prec} = \frac{\mathrm{Pt} \cdot \mathrm{G} \cdot \sigma \cdot \mathrm{Ae}}{16 \cdot \pi^2 \cdot \mathrm{L}} \times \frac{1}{\mathrm{R}^4}$$

Other questions might require more thought and understanding of basic principles.

A room 3m x 2m x 2m is perfectly sealed thermally – no heat can get in or out.

A small refrigerator is in the centre of the room and the 100W motor is 100% efficient, but the door is left open. A 1 kg pack of butter is in the refrigerator; after a week will the butter be hard or soft?

As the examinee looks at the problem, they may like to ask for help and so some clues can be offered. Although penalty marks might be deducted, just seeing how many clues were required and how far they proceeded with those clues gives an insight into

their abilities to think laterally and apply knowledge as opposed to those just good at bookwork.

		max. marks obtainable
Clues:	nil	20
- 2;	consider energy	18
- 5;	consider what is happening to the energy the motor is using as it pumps refrigerant around the cooler	15
-10;	the motor is doing work all the time. This work is converting electrical energy into heat, which cannot escape	10

Traditionally, in engineering examinations, marks are awarded for answers that follow a required path, calculating along the way, to find a numerical answer. Sometimes, under pressure, mistakes are made which mean that the correct answers are not obtained. Why not look for method instead and ask a candidate to describe how he or she would go about solving the problem? The unknowns could be identified and the steps to find them be written down, so if a candidate could not remember the exact equation, for example, at least they could get credit for knowing that it was necessary. In work, being able to identify the problems and the tasks required to solve them and knowing who to ask or where to find the information, is important because it means an employee or graduate has access to a far larger database than their own memory and experience and the problems are more likely to be solved and cross fertilisation is a good source of new ideas.

In innovation, especially, it is often cross disciplinary work that is vital to finding new markets and products. Identifying the employees who can sense what is required and who can direct a team to work together across disciplines is more important than finding someone who can remember all the details of their own education within their own discipline. Referring back to Fig. 1, it is important to identify those who are moving towards the top right hand corner of the diagram, rather than those who are progressing straight up the knowledge axis, since the former will know how to access and integrate the knowledge of the latter.

Following this argument, open book exams are more representative of everyday problem solving and test a candidate's ability to search out information. In addition, why not let them discuss the questions with other candidates over tea or coffee and then revisit their papers, if necessary, as they would in an office or laboratory?

Taking a student out of their comfort zone into unfamiliar territory can be a way of seeing how they respond to change and new ideas and concepts. A multimedia tutorial could be given e.g. for an electrical engineering graduate, the tutorial could be on electrochemistry, astronomy, agriculture or even a topic such as art history. There would be questions to answer throughout and which must be passed to continue. By studying the number of attempts at the questions and how often they have to re-visit the tutorial, a candidate's ability to understand a new situation can be ascertained. Fig. 6 (representative – not from results) shows that candidate X is clearly able to process and absorb new ideas quickly, whilst candidate O has difficulty with new concepts.

Question number	Number of attempts			
	1	2	3	4
1	X			O
2		X	O	
3		X		O
4	X			O
5	X		O	
6	X			O
7	X			O

Fig. 6. A representative diagram showing how two candidates X and O might respond in different ways to an unfamiliar subject

3. Summary

Traditional universities are well established offering degree courses in fixed locations, but there are, however, various routes to HE and these will increase in number. There are growing political and commercial pressures appearing in higher education and the advent of modern technologies means there will be many routes to a degree course and this will, inevitably, mean variations in standards. Not all educational attainments are to degree level, however, and there are many ways that employers can improve the education standard of their workforces. Given all the new ways to receive an education or training, and the global nature of knowledge provision and employment, trying to accredit all the routes a candidate might take to gain the knowledge and experience required for problem solving within employment becomes an impossible task.

Independent institutes are required to set a set of reference standards against which educational attainments are judged. These standards should examine the candidates learning outcomes and not be an assessment of the paper work generated by the learning providers. The standards should determine a range of skills of a graduate, not just their knowledge. The institutes must remain independent and only concerned with verification. They should not be involved in education provision in any way, nor in any other commercial activity likely to cause a conflict of interest.

When assessing candidates, traditional examinations can be put aside or modified to ascertain a candidate's ability to identify problems and the resources necessary to solve them. Giving clues, asking for methods and not necessarily the solutions and allowing questions or tasks to be discussed between candidates before final submission of results could be ways in which the 'War on Talent' could be pursued. In addition, taking candidates out of their normal comfort zones, can give valuable information about their initiative, ability to absorb new ideas and flexibility.

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