Chapter 20
Towards an Efficient Approach for Examining Employability Skills

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Abstract A student’s approach to an open-ended problem, one with no necessarily right or wrong answer, is crucial to their employability. Indeed the value of a mathematics graduate to an employer is in his/her problem solving skills, and exercises assessing these usually form part of graduate assessment days. The scope for open-ended problems within a mathematics degree is large, yet traditionally these and other transferable skills are not extensively assessed until final year projects. The post-2012 funding shift has significant implications for student recruitment and a fundamental change in the treatment of employability skills is needed in response. The assessment of transferable skills is always possible within extended pieces of coursework, but the marking of these requires a substantial time commitment from staff when class sizes are large. This small study looks at whether it is possible to assess the skills associated with open-ended problems within traditional and time-efficient examinations.

20.1 Background and rationale

With the recent shift in undergraduate funding, the future success or failure of a university department has been placed in the hands of student recruitment and league table performance. The employability of graduates has therefore never been more important. But how should mathematics departments encourage and assess these skills in their students in a time efficient and scalable manner?

Along with communication skills, a student’s approach to an open-ended problem, one with no necessarily right or wrong answer, is crucial to their employability. Indeed, the value of a mathematics graduate to an employer is in his/her problem-solving skills and the ability to communicate results, and these are usually the focus of graduate assessment days. There has always been scope for the use of open-ended problems in mathematics degrees, particularly within applied mathematics streams,
yet traditionally these skills are not extensively examined until final year projects. A fundamental shift in the treatment of these and other employability skills is needed.

The assessment of problem solving skills is clearly possible by extended pieces of coursework or ‘mini-projects’ within modules. However, marking these requires a significant time commitment from staff when class sizes are large; as well as being educationally sound, assessment must be practicable. This leads us to question whether it is possible to assess some employability skills within traditional examinations.

This report presents a comparative study of two cohorts of students and their solutions to open-ended problems, both in terms of their approach to the problem and the reporting of their results. One cohort is examined through the use of a 3,000 word mini-project over the semester; the other is examined within a traditional unseen examination. Despite being limited in its scope, this study should be considered as part of an on-going investigation into the effective and efficient assessment of employability skills.

20.2 Implementation

The study compares the summative attainment of two cohorts of students, both enrolled on a module called *Theory of Interest*. The module is an MSc level course within Leicester’s MSc Actuarial Sciences and MSc Financial Mathematics & Computation programmes, however undergraduates are allowed to take it in their final year. Some 37 MSc students (henceforth referred to as PGs) and 87 undergraduates (UGs) took the module this year; these formed the two separate cohorts.

The module is taught in a non-traditional way in that a specifically written textbook is given to the students at the start of the course. Each week a lecture is given on the salient ideas and concepts of a particular chapter, and is delivered with the assumption that the students have already independently studied the material in detail. Furthermore, a weekly problem class is given where questions of examination standard are discussed; again it is assumed that the students have already attempted these questions in advance. The lectures and problem classes are common to both cohorts (PGs and UGs). This approach has the specific aim of instilling independent-learning skills into the students in preparation for professional studies after graduation. This approach has been taken for the last three years and has proved successful and enjoyable, particularly for motivated students. However, a discussion of this aspect of the module is not the aim of this report.

With regards to the assessment of the module, the PGs were assessed by an extended mini-project over the semester and a two-hour unseen written examination consisting of four compulsory technical questions at the end of the semester. The UGs were examined by a three-hour unseen written examination alone, consisting of the same four technical questions and an additional open-ended question, at the end of the semester. The additional examination question was closely related to the PGs’ mini-project and both are included in the appendix for reference. Note
that the use of compulsory examination questions deviates from typical practice in mathematics programmes and is again intended to prepare students for professional examinations after graduation.

Marking schemes for the open-ended question and mini-project were written to reflect the skills being assessed in each cohort and these are summarised in Table 20.1. Given the very different context of each assessment, the skills do not overlap entirely. The skills common to both cohorts were:

- interpretation of data and information presented in an unfamiliar way (element 1);
- selecting appropriate tools to make an analysis (element 2);
- accurate use of mathematics (element 3);
- forming a decision based on the results of the analysis (element 5).

Both assessment types required the communication of a justification of the methods used in their analysis and justification of their recommendation (element 4). However the target (small business owner vs. academic examiner), style and extent of the required communication were different between the cohorts, and element 4 was not considered as common. The skills being assessed are further discussed in the Evaluation section below.

<table>
<thead>
<tr>
<th>Element</th>
<th>Weighting</th>
<th>UG cohort</th>
<th>PG cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>10%</td>
<td>Correct interpretation of information provided</td>
<td>Correct interpretation of information provided</td>
</tr>
<tr>
<td>2.</td>
<td>25%</td>
<td>Correct choice of mathematical tools</td>
<td>Correct choice of mathematical tools</td>
</tr>
<tr>
<td>3.</td>
<td>25%</td>
<td>Accurate use of mathematical tools</td>
<td>Accurate use of mathematical tools</td>
</tr>
<tr>
<td>4.</td>
<td>30%</td>
<td>Justification of approach and recommendations</td>
<td>Justification of approach and recommendations. Appropriate targeted communication style throughout</td>
</tr>
<tr>
<td>5.</td>
<td>10%</td>
<td>Clear statement of recommendation</td>
<td>Clear statement of recommendation</td>
</tr>
</tbody>
</table>

Table 20.1 Assessment elements for each cohort

To facilitate marking, detailed mathematical solutions were produced for all calculations students could have attempted, although it was by no means required that students perform all these calculations if adequate justification was given. Given the significant amount of subjective assessment arising from this aspect and the communication skills required in general, the same examiner was used for both cohorts to ensure consistency. It is important to state that the examiner has significant experience within the financial industry and understands the communication skills required, which are very different for those required for the publication of academic papers, for example.
20.3 Evaluation

20.3.1 What skills were assessed in each cohort?

In order to clarify its approach to the development of employability skills at the programme level, Leicester’s mathematics department has taken the Great Eight Competencies (Bartram, 2005) as the definitive statement of those fundamental characteristics that underpin job performance. It is useful at this stage to consider how the skills being assessed in this study link back to these competencies. Reference back to this set of competencies is common practice within the department, particularly in the development of new modules with significant skills content.

The competencies relevant to this study are summarised in Table 20.2, where the assessment element refers to that in Table 20.1.

<table>
<thead>
<tr>
<th>Competency</th>
<th>UG assessment</th>
<th>PG assessment</th>
<th>Assessment element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leading and deciding</td>
<td>✓</td>
<td>✓</td>
<td>1, 5</td>
</tr>
<tr>
<td>Support and cooperating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interacting and presenting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysing and interpreting</td>
<td>✓</td>
<td>✓</td>
<td>2, 3</td>
</tr>
<tr>
<td>Creating and conceptualising</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organising and executing</td>
<td>✓</td>
<td>✓</td>
<td>4</td>
</tr>
<tr>
<td>Enterprising and performing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 20.2 Bartram’s Great Eight Competencies

We consider each of those competencies represented in this paper in more detail:

Leading and deciding: Takes control and exercises leadership. Initiates action, gives direction, and takes responsibility.

Despite the level of communication required, intended audience, and time spent conducting the analysis being very different, both cohorts are required to make and justify a decision based on their analyses. Furthermore, both tasks require students to interpret the information and data given to them in an unfamiliar way: as mathematics students, they are not often confronted with blocks of text containing both relevant and irrelevant information. This competency is therefore associated with assessment elements 1 and 5 and can be compared directly across the cohorts.


This competency is relevant to both cohorts and forms the focus of this assessment: selecting and correctly using technical expertise in an unfamiliar situation. It is therefore possible to compare this competency across the cohorts. This competency is associated with assessment elements 1, 2 and 3. Note that the distinction in the communication aspects has been placed under the Organising and Executing competency below.
Organising and executing: Plans ahead and works in a systematic and organised way. Follows directions and procedures. Focuses on customer satisfaction and delivers a quality service or product to the agreed standards.

Clearly the need for time management and planning arise in both cohorts, although with distinctly different time frames. Furthermore, for the UG cohort, the time management issue is for the entire 3-hour examination and the skill within the context of the particular question cannot be isolated for comparison. More importantly, with regards to the customer satisfaction aspects of this competency, the PG task requires the students to write a report with a particular audience in mind. In this particular assessment it is the small business owner, but it could also be a manager, academic, government representative, for example, each of which require different uses of language and descriptions of technical concepts. For the UG task, a simple recommendation and justification is required to be communicated to the academic examiner. The communication aspects of both tasks are therefore fundamentally different and it is not possible to directly compare achievement in this competency across both cohorts, despite it being present in both. This competency is associated with assessment element 4.

20.4 How did the students perform?

A comparison of the summative attainment of each cohort is not an adequate way of determining the success of the assessment for assessing particular skills. However, this information is given in Table 20.3 for completeness.

<table>
<thead>
<tr>
<th>Assessment element</th>
<th>UG cohort (87 students)</th>
<th>PG cohort (37 students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>61%</td>
<td>49%</td>
</tr>
<tr>
<td>2.</td>
<td>58%</td>
<td>65%</td>
</tr>
<tr>
<td>3.</td>
<td>68%</td>
<td>72%</td>
</tr>
<tr>
<td>4.</td>
<td>65%</td>
<td>53%</td>
</tr>
<tr>
<td>5.</td>
<td>85%</td>
<td>75%</td>
</tr>
<tr>
<td>Overall</td>
<td>66% (sd 30%)</td>
<td>63% (sd 15%)</td>
</tr>
</tbody>
</table>

Table 20.3 Summative attainment by assessment element

A comparison of the data in Table 20.3 is difficult because the two cohorts reflect differently qualified students, i.e., the intake for the MSc necessarily filters those students of 2:1 standard and above. This has implications for attainment in the mathematical aspects (element 3) as one might expect the UGs to have weaker mathematical skills than the PGs. Furthermore, the PG cohort has a significantly larger number of overseas students without English as a first language; this has implications for the communication aspects (elements 1, 4 and 5). Both of these issues are anecdotally represented in the data, although no statistical significance is sought for this claim.
Despite having similar averages, the attainment of the UG cohort has a much greater standard deviation around the average than the PG cohort.

20.5 How successful has the UG assessment been in assessing the competencies, relative to the PG assessment?

Clearly the mini-project approach is a better simulation of work: students have access to reference material, have longer timescales, are able to discuss the issues with colleagues, and are required to report the findings with a particular target audience in mind. Furthermore, as the project is completed over an extended period of time, the students are confronted with conflicting deadlines and are required to plan their time and priorities effectively. Such projects should therefore be widely used within mathematics programmes. However, marking the reports is a significant time burden on academics and it is not practicable to include these in every module. In terms of time spent marking during this study, each mini-project took in excess of 30 minutes to read and grade. In contrast, each examination question took around 10 minutes to read and grade.

We proceed to discuss each assessment element from Table 20.1 in turn, paying particular attention to the success of the UG assessment method compared to the PG assessment method. Recall that the aim of this study is to see in what instances the examination-question approach is a suitable alternative to the mini-project approach.

Element 1: correct interpretation of information provided

The same misinterpretations of the information provided in the question occurred in both cohorts, but surprisingly this occurred more often in the PG cohort. Whether this is due to the particular students involved, or was due to the students having more time to overanalyse and confuse themselves over the information is unclear. However, given that the mistakes were common to both, we conclude the UG assessment to be an equally valid means of assessing this competency.

Element 2: correct choice of mathematical tools

The assessment element was twofold. First, the students were expected to think about the investment opportunities available to them and judge their feasibility before performing the mathematical analyses. Indeed a number of the opportunities could be discounted immediately without a full analysis. Second, for those opportunities worthy of mathematical analysis, were appropriate techniques used?
On the whole the PG cohort was less likely to blindly proceed down the mathematical route without reference to practical or commonsense considerations. However, the stronger students from the UG cohort did justify their reasons for not performing analyses better than the PG cohort. Overall both cohorts used the appropriate range of mathematical tools for each analysis.

As with the element 1, given that both cohorts demonstrated a similar range of answers (both correct and incorrect), we conclude the UG assessment to be an equally valid means of assessing this competency.

**Element 3: accurate use of mathematical tools**

Despite the slightly better achievement of the PG cohort on average with regards to this assessment element, the accurate use of mathematics is clearly assessable in both assessment types.

**Element 4: justification of approach and of recommendations (and appropriate communication style throughout)**

As discussed previously, it is inappropriate to compare this element across the cohorts. However, in terms of student performance within each cohort, the UG cohort typically performed well, but with a broad range of quality as would be expected from a large UG class. The PG cohort performed poorly compared to expectations, however this was to do with their ability to convey mathematics to a non-specialist audience. We conclude that both assessment types were adequate to assess their very different objectives, with the PG assessment having significant benefits for the assessment of communication skills relevant to employability.

**Element 5: clear statement of the recommendation**

Implicit in each assessment was the need to summarise the findings. Typically both cohorts performed this well, although different types of summaries were required given the different contexts. Many UG students were in the habit of summarising the main result of their solution as part of good examination technique, and we conclude that the UG assessment is an equally valid means of assessing this element.
20.6 Discussion, learning and impact

This study has been successful in determining that a number of employability competencies can be assessed efficiently within traditional unseen examinations by the use of open-ended questions. This method has the advantage of being a much more time efficient means of assessment compared to the use of mini-projects. Within the confines of this particular study, open-ended examination questions have been shown not to be a valid substitution for the assessment of report writing skills, but that is not to say unseen examinations could not be used to assess other written communication skills. Furthermore, in the context of studying the assessment of all employability skills (as summarised by the Great Eight Competencies), this study is limited. It should be emphasised that this particular study did not cover all the eight competencies and Table 20.2 shows those not considered here. Those missing are typically focused on inter-personal interactions and such skills are best assessed in terms of group work.

Looking at the assessment of employability skills at the programme level, we have shown that assessment of some competencies need not be confined to modules explicitly focused on transferable skills or extended projects, as has tended to be the traditional model. Instead some employability skills can be distributed evenly over a programme and assessed implicitly in the examinations of traditional, technical lecture courses. Explicit modules or elements of modules are required to facilitate the assessment of report writing and group work skills, and the time cost of this is unavoidable.

It is important to note that this study has been concerned with the assessment of employability skills, not the development of employability skills. There is huge value in the provision of problem-based modules to help develop particular skills in students, but it is important that these skills are not left to these modules alone. Regular reinforcement through problem classes and assessment within the examinations of as many modules as possible are to be desired.

A significant barrier to the successful inclusion of employability skills within mathematics and other science programmes is the competence of academic staff. It is clear that academia is only one career option open to graduates, and the skills necessary for success in academia are often distinct from those required in other professions. For example, an academic paper is written entirely differently to, say, a report to a client uneducated in the subject of the report. Despite being skilled in what they do, the relatively narrow skill set of many academics with regards to general employability skills necessitates closer links with employers.

20.7 Further development and sustainability

The results of this study have been fed into the design of a new programme at Leicester, BSc Mathematics and Actuarial Science, to be launched in October 2012. The programme is different from standard mathematics programmes in that it has
a clear vocational aim, despite also being academically rigorous. The design of the programme includes the provision for regular and explicit skills modules, and also many modules have been developed with time allocated to the practice of transferable skills, including group work, report writing, presentation and problem solving. The assessment of each individual module will encourage employability skills through continuous assessment marks and also the use of open-ended examination questions as discussed in this paper. The launch of this programme leads to opportunities for further comparative studies in the effectiveness of assessment schemes for employability skills in the coming years.

References


Appendix

Scenario

On 1 April 2011 you are appointed financial adviser to the owner of a small shoe-making business. The business is based in a small village and employs the vast majority of the inhabitants of the village. The village is in a reasonably remote part of Scotland with poor transport links. The business currently makes £200,000 pa profit (after salaries and all operating costs), which is projected to continue for the foreseeable future. Your client’s risk-averse nature means that he has a friendly relationship with his bank that provides a business account which earns 2% pa on any deposits, and a rolling loan agreement which charges 4% pa on any borrowings. In previous years the owner simply invested any profits in the deposit account which had a balance of £4.5 million just prior to reinvesting all this in new premises for the factory. The new premises are now fully operational and the business has zero borrowings and cash holdings.

Your client has decided that the company’s future profits ought to be put to better use and has brought to you the following investment/business opportunities to advise on:

(a) Immediately invest £300,000 in a 10-year government bond which promises coupon payments of 2% pa.
(b) Immediately invest £200,000 in a 25-year bond issued by a new mining firm which prospect for a rare mineral in a remote part of the Highlands of Scotland. The bond promises to pay coupons of 4% pa.
(c) Temporarily diversify the shoe-making business into high-tech electronics. The venture requires a single initial investment of £200,000 for new machinery, and is expected to break even for the first 5 years before making an annual profit of £10,000, increasing by £10,000 pa for the following 9 years (i.e. 10 profitable years in total). After 15 years the machinery will be obsolete and have an estimated scrap value of £5,000. New employees with specialist skills would be required from the outset and the salary cost of these has been factored into the given data.

(d) Diversify the product range into leather boots. This requires a single initial investment of £100,000 for new machinery and training of existing staff. The new line is expected to break even for the first 2 years before making an annual profit of £10,000 which is expected to increase at 3% pa for the foreseeable future. The machinery is expected to last for many years with only minimal maintenance costs, which are factored into the projected figures.

(e) Invest any profits earned over the year in a diversified portfolio of FTSE 100 shares.

**Undergraduate examination question:**

Determine which, if any, opportunity your client should invest in. Present any calculations and/or discussions to justify your decision.

**Hint:** Note that there is not necessarily a right or wrong answer for this question; marks are awarded for sensible discussions and relevant calculations.

**Total:** 20 marks

**Postgraduate mini-project brief:**

Write a report to the owner of the business, detailing your advice and recommendations. Any mathematical analyses should be attached as an appendix to the report. Despite running a successful business, you should assume that your client is not financially sophisticated and has only a vague understanding of investment jargon.

**Hint:** Note that there is not necessarily a right or wrong answer, and marks are awarded for sensible comments and relevant calculations. Consideration should be given to strategic fit, feasibility and impact on the local community, as well as financial issues.

**Total:** 100 marks