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Making a maths degree work for the workplace

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ABSTRACT
This article will provide ideas for teaching methods that aim to provide undergraduate students with the experience of working with mathematics in a business context. These teaching methods have been employed at a mainstream U.K. university in a final-year module, and employers have been heavily involved in designing and assessing learning activities. The student feedback and reflections on these activities will be presented in this case study.

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Introduction

The need for higher education institutions to provide students with opportunities to enhance their professional skills alongside traditional subject knowledge and skills has been driven by employers, students themselves and the weighting given to graduate employment in various university league tables. Employers have noted that graduates are technically competent but are lacking key professional skills (Lowndes & Berry, 2003). It has been reported that few recent graduates believe that their degrees have developed skills that are of importance in the workplace, although students who are surveyed before graduation are more likely to have a clear recollection of activities in their degree course that have helped develop their employability skills than graduates who are in employment. Research has shown that graduates in employment associate any skills development with experiences of explicit work-based training, and as time since graduation increases, this attribution of skills development to in-work experiences is more prevalent (Fallows & Steven, 2000; Inglis, Croft, & Matthews, 2012).

In response to concerns surrounding professional skills development, many higher education institutions have sought to embed these skills within courses or offer sessions on specific skill areas as stand-alone sessions (Cranmer, 2006). The strategies have expanded, and various degrees of embedding are recognised, including total embedding, explicit embedding and integration, and parallel development (DfEE, 1997). In mathematics, these embedding efforts have included the use of alternative methods of assessment within taught modules to encourage skills development alongside mathematical content (Waldock, 2011). Explicit embedding and integration of professional skills development within taught modules have been identified as important aspects of

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this endeavour in mathematics. Waldock observes that this embedding can help students see the wider purpose of each activity in developing their graduate attributes.

It has been observed that group work can be utilised to promote active learning of mathematics and an appreciation and acquisition of the associated skills (Hibberd, 2002). It has also been noted that students can value advice from industrial representatives over that from academics or careers staff (Chadwick, Sandiford & Percy, 2011; Cranmer, 2006), indicating that any efforts to focus on professional skills development should perhaps involve combined efforts in collaboration with industry.

Course structure

This case study focuses on one specific aspect of a wider effort to embed professional skills within the mathematics programmes at a mainstream U.K. university. A strand of skills modules was developed, and these were first offered to students in the 2012/13 academic year. The university has many optional modules, covering pure mathematics, applied mathematics and statistics. Students can opt to specialise in particular branches of mathematics in the third year. An overview of the programme for Single Honours and Combined Honours students is provided in Table 1.

Pedagogical framework for the new strand of modules

It has been acknowledged that there is variation across the sector when introducing employability into programmes, and this is attributed to the range of curricula found across institutions. It was recommended by the Confederation of British Industry (CBI) and Universities UK (UUK) that each institution should reflect on their own provision

Table 1. Programme structure for Single Honours and Combined Honours students.

	SINGLE HONOURS		
	Semester One	Semester Two	Skills Modules
Year 1	Students take four modules, all compulsory	Students take two compulsory modules and two optional modules, which can be elective choices from a range of different departments across the university	Skills strand module is available as an option in Semester Two
Year 2	Students take four modules, all compulsory	Students take three compulsory modules and one optional module from a choice of three	Skills strand module is compulsory in Semester Two
Year 3	Students take four optional modules from a choice of seven	Students take four optional modules from a choice of eight	Skills strand module is available as an option in Semester One
	COMBINED HONOURS		
	Semester One	Semester Two	Skills Modules
Year 1	Students take two compulsory modules	Students take two compulsory modules	None
Year 2	Students take two modules, one compulsory and one optional module from a choice of three	Students take two optional modules from a choice of six	Skills strand module is available as an option in Semester Two
Year 3	Students take two optional modules from a choice of seven	Students take two optional modules from a choice of eight	Skills strand module is available as an option in Semester One

of employability skills and aim to identify suitable methods for improvement in line with the needs and ethos of the particular institution (CBI and Universities UK, 2009).

Bridgstock (2009) recommends that students be introduced to employability skills early in their studies and that the importance and relevance of these be emphasised regularly throughout the course of the degree programme. Bridgstock argues that development of these particular skills is 'an ongoing process of engaging in reflective, evaluative and decision-making processes using skills for self-management and career building'.

The university in this study introduced a strand of activity across the institution, which sought to emphasise employability and skills development as a core part of the student experience. Individual departments were asked to respond to the requirements set out in this new strand of activity and develop their programmes where appropriate. The skills strand of modules developed by the Mathematics department followed an explicit embedding and integration approach, with one skills module available in each of the three undergraduate years.

It has been argued that a wide range of teaching approaches and activities should be used when aiming to develop employability skills. Knight et al. (2003) note that 'unless students experience such kinds of learning, teaching and assessment approaches, it is hard to see how higher education contributes to the achievements valued by employers'.

Inquiry-based learning can empower learners and encourage the development of employability skills through individual construction of knowledge alongside peer interactions in group work (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010; Cobb, Yackel, & McCain, 2000). The four different levels of inquiry detailed by Banchi and Bell (2008) provide a framework, with many of the tasks in the first- and second-year modules being classed as structured inquiry or guided inquiry projects.

Constructivist approaches to teaching and learning are aligned with the development of employability skills as they 'encourage exploration, provide feedback and develop reflection, motivation and engagement' (UKCES, 2008).

Each of the modules in the skills strand incorporates an element of action research (Bradford, Gibb, & Benne, 1964; French & Bell, 1978; Froham, Sashkin, & Kavanaugh, 1976) where students work on group projects and carry out extended investigations into real-world problems.

Development of the final-year skills module

The module that was introduced as a final-year option is the main focus of this case study. This module has a particular focus on professional skills, specifically those required by mathematicians working in business and industry. Explicitly, the final-year module aims to

- develop students' ability to communicate mathematical results to audiences of differing technical abilities, including other mathematicians, business clients or the general public;
- develop problem-solving abilities and the ability to select appropriate techniques when applying mathematics to real-world phenomena;
- develop an appreciation for the different skills required to successfully operate as a team; and
- develop reflective practice, particularly reflective writing.

Teaching and learning methods

The development of employability skills is a central focus in this module, and the intended learning outcomes clearly articulate this to students. Making this focus explicit in the module details is in line with recommendations made by Knight et al. (2003).

The inclusion of reflective assignments in the assessment for the module aligns with Pegg, Waldock, Hendy-Isaac, and Lawton (2012) and recommendations from UKCES (2008). Pegg et al. observe that 'the importance for a learner of reflecting on past developments, and recognising how far they have come, should not be underestimated. It is easy to undervalue past achievements and current skills, regarding skills yet to be gained as somehow more worthy; however, a clear awareness of skills already gained, together with the ability to clearly articulate and evidence where, and how, they were acquired helps to build self-confidence and provide a solid foundation for future skill development and improved graduate employment prospects.'

The need to fully embed skills development within programmes and to emphasise the discipline-specific context is noted by UKCES (2008), Waldock (2011) and many others – 'the context in which particular skills are demonstrated is essential to learning and embedding them, and educators should carefully consider the context-related implications of the skills that they aim to promote' (UKCES, 2008). In this final-year module, skills development is central, but the development is encouraged through tackling rich mathematical projects.

A phased inquiry-based model was developed for the final-year module. In particular, the group projects set in the module follow a progression from structured inquiry (the questions and some of the outline are provided to students) to guided inquiry (only the research questions are provided and the approach is then determined by the students) and, finally, open inquiry (the research questions and approach to tackling these are determined by students themselves).

The aim of this approach is that the gradual shift to open inquiry should enable students to reflect on their progression and development in tackling these extended projects. In this model, cognitive scaffolding (Vygotsky, 1978; Wood, Bruner, & Ross, 1976) is employed. Students are guided with the initial group projects towards clearly defined objectives and goals. This is encouraged through the provision of detailed briefing documents with structured project questions. The level of detail in the briefing documents and the number of associated prompts are gradually reduced as capabilities and competencies develop (in line with recommendations in UKCES, 2008).

The structure here could also be viewed as an action research approach that aims to ultimately foster elements of appreciative inquiry (Cooperrider & Srivastva, 1987). This is to be achieved through the phased inquiry-based project approach detailed above, which will grant the students opportunities for creativity and genuine discovery in their work as the projects progress. It is hoped that the sustained emphasis on reflection throughout the module will encourage students to acknowledge any new development in their skills and abilities.

The module has been running for five years now, and the discussion presented in this case study relates to the running of the module in the 2016/17 academic year. In this year, 44 students (out of the 112 students in the year group) were enrolled on the module. Thirty-five of these students were Single Honours students, and the remaining nine students were Combined Honours students. The lecturer used their knowledge of the students involved to create equally balanced groups.

Assessment structure

Group organisation is an important aspect of the projects, and students must keep a formal record of all group meetings (including agendas, minutes and action points). This forms part of the assessment and encourages students to manage their work effectively by identifying key tasks that need to be completed in order to make progress towards the overall objective. Students must also distribute these key tasks appropriately between group members, with the aim of promoting a greater awareness of individual skills and strengths.

The final-year module is assessed by three group projects and four individual assignments. Some of these individual assignments are focused on topics similar to those found within the group projects, whereas others are reflective pieces prompting students to discuss the development of skills through the activities in the module. A summary of the assessment in the module is provided in Table 2.

As discussed previously, the assessed work for the module often takes the form of essays or reports. To help students understand the marking of these, grade-based marking criteria were created and are provided to students in the early stages of the

Table 2. Assessment structure for the final-year module.

Assessment Component	Description	Outputs	Intended Learning Outcomes
Group Projects (70% of module mark)	Three group projects: **Project 1 (3 h)** Time-restricted project **Project 2 (2 weeks)** Client project **Project 3 (6 weeks)** Formal mathematical research project	Written reports (for either client reader or a more mathematical audience), group presentations (again to be aimed at specific audiences)	• Identify appropriate techniques and apply mathematical knowledge to solve problems related to real-world phenomena • Produce tailored reports based on the development of a piece of work aimed a specific intended audience • Communicate mathematical results to audiences of differing technical abilities using a variety of methods
Individual Assignments (20% of module mark)	Four individual assignments set at regular intervals throughout the module	Short reflective essays (300–500 words) or brief mathematical reports related to project work	• Reflect on skills and identify areas for development • Communicate mathematical results to audiences of differing technical abilities using a variety of methods
Management of group projects (10% of module mark)	Formal record of group management of the group projects	Record of group meetings and associated documents (agendas, minutes and actions)	• Reflect on progress of tasks over an extended period of time and determine appropriate actions • Communicate mathematical work and results in suitable formats • Reflect on skills and identify areas for development

Table 3. Assessment criteria used in the final-year module.

UG Award	Example Descriptors	Possible Outcomes (%)
First	• In-depth understanding of the underlying concepts and significant signs of originality • Well-structured, robust and persuasive argument in accordance with relevant theories and concepts • Demonstrates the ability to interpret and present concepts in a critical and constructive manner	100, 90, 80, 75, 72
Upper Second	• Develops and analyses the core issues while dealing with some advanced aspects of the assessment topic • Good communication skills with clear presentation of argument/analysis • Good analysis and well-organised argument, supported by relevant evidence	68, 65, 62
Lower Second	• Knowledge of a sufficient number of core materials • Arguments are well constructed but do not develop sufficiently some significant issues • Clear style with satisfactory presentation	58, 55, 52
Third	• Some knowledge of a restricted range of issues relevant to the assessment • Some development or illustration of points • Arguments are poorly constructed with weak/simplistic presentation	48, 45, 42
Fail	• Poor/inappropriate presentation • Significant errors or misconceptions with respect to a core issue covered by the assessment • Little evidence of coherent thinking or organisation of arguments	38, 30, 20, 10, 0

module, with grades corresponding to final degree classifications. Illustrations from the grade-based criteria can be found in Table 3.

Client project

Each of the group projects in the module requires students to explore a different aspect of working in a mathematical consultancy. The client project aims to provide students with experience of producing a variety of outputs that have to be tailored to a specific client audience. In the 2016/17 academic year, the client role was played by an industrial partner who set the task for students in one of the class sessions. Students were provided with customer sales data for one particular month. The groups had to perform an analysis of the data and make some recommendations based on this. Outputs were to take the form of a written client report and a group presentation given to the client. Groups were given two weeks to work on this project. The report was worth 60% of the project mark, and the presentation was worth 40%.

Students were briefed on the expectations for the various outputs by the client and the lecturer. The emphasis in this initial briefing was on the considerations required when creating a document or a presentation for a non-mathematical audience. Explicitly, it was to be assumed that the client was working for the business in a managerial role rather than a mathematical role. It was emphasised to students that the challenge with this project would be successfully justifying any recommendations to the client using appropriate language, while still making clear references to mathematical work.

In their work on this project, students applied existing statistical knowledge and were not required to learn any new statistical techniques. Groups had to decide which comparisons to consider and which tests to conduct. The emphasis with this project was on the relevance of any mathematical work, and students were encouraged by the client to consider the results that would be the most illuminating for the business. As the time for the project was limited to two weeks, the client encouraged students to consider the business perspective and associated priorities. It was hoped that this would focus attention on important messages held within the sales data, which could be informative for future marketing decisions, for example.

Formal mathematical research project

The third group project is a formal mathematical research project and also aims to simulate the experience of working within a mathematical consultancy. In this project, groups have to determine their own research question to investigate in an unfamiliar topic area. In the 2016/17 academic year, groups were provided with raw radar data collected from the same location on two different days and were also provided with instructions on how to display the data in a variety of formats.

Groups were asked to submit project proposals in the second week of the project (after having received the raw data in the first week) and had six weeks to carry out the research. Students were offered advice from both the lecturer and the domain expert on their proposals, and drafts of these were scrutinised by both before they were formalised. Specific advice was provided on whether the goals were achievable in the time. It was understood that this was something that the domain expert would be able to provide guidance on and students would not necessarily realise the practical aspects of working with the data at the beginning of the project.

In the end, three distinct project areas (in the broad sense) were investigated by the seven groups in the class. As the projects progressed, some groups were able to extend their initial proposals and conduct additional work based on their own ideas and observations from the raw data.

Once again, a report and an oral presentation were required. The report in this project was to be of a more mathematical nature, and greater technical detail was expected in comparison with the client report from the previous project. In particular, any formal mathematical definitions and formulae required a clear explanation in the report, and full details of any calculations were expected. This was not the case for the client report, where a summarised justification was expected, rather than extensive details of mathematical calculations.

The oral presentation in this project was to be aimed to a general public audience rather than a specific client audience. It was hoped that this element would encourage the students to focus on the key messages of their mathematical work and present these in a format that would be engaging and at an appropriate level for the intended audience. As with the second project, the report was worth 60% of this project mark and the presentation was worth 40%.

The industrial partner for this project also acted as the domain expert and could be contacted by the groups throughout the project. The domain expert set the task in the initial class session but did not make any guarantees about being physically present in any of the other sessions. Incorporating a forced distance between the domain expert and the groups was an intentional, as well as a necessary aspect of the project. Explicitly, the domain expert was unable to physically attend sessions due to his schedule, and it

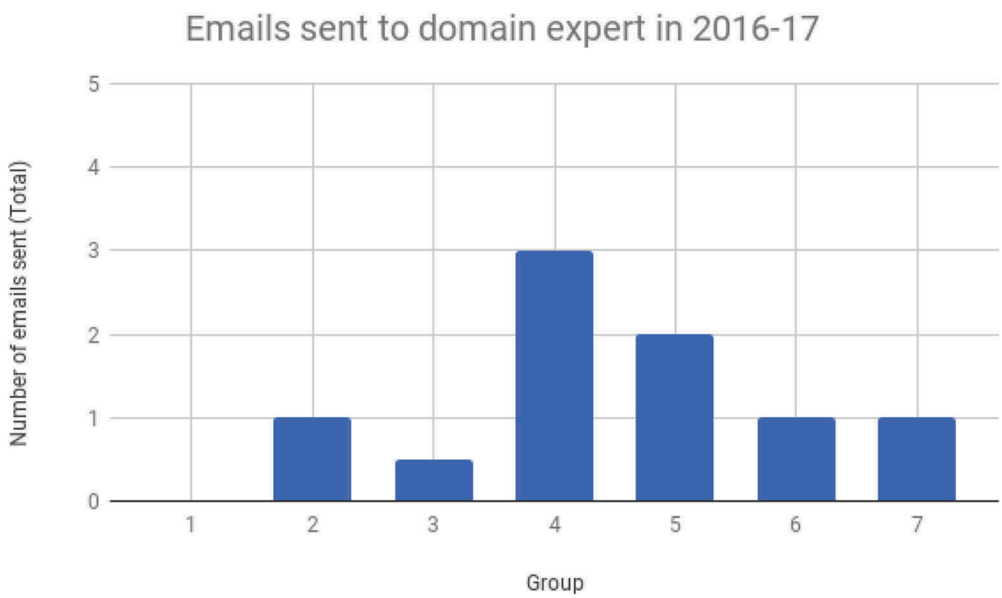

Figure 1. Costed emails to the domain expert.

was felt by the expert and the lecturer that this element contributed to the realism of the task.

To emphasise the distance aspect, a costing was introduced for contact with the domain expert. Each group could contact the domain expert via email five times at no cost. If more contact with the domain expert was needed, a further five emails could be sent with each of these 'additional' emails bringing the report deadline forward by one day. It was hoped that this procedure would encourage students to manage their project work very carefully and persevere with tasks, exploring alternative methods and ideas before deciding that help is definitely required to make progress. No groups used all of their five free emails, and one group did not send any emails at all to the expert.

As can be seen in Figure 1, three of the groups only used one of their emails, and the most emails sent by a single group was three. There was also one group who were charged for half of an email as the domain expert decided that the help requested did not account for the cost of a full email. It was explained to the groups that an email would be charged if the request associated with the email required approximately 10 minutes of work to investigate and deliver a response.

A crucial element in this project is the open inquiry aspect. The aims and objectives for the research are set by the students, and so the ownership of and responsibility for the project lie with the groups themselves. It is hoped that this setup will empower students and provide a genuine sense of achievement and discovery when progress is made.

Table 4. Median student self-assessment scores from week 2 and week 11.

Professional Skill	Median Score (Week 2)	Median Score (Week 11)
Self-management	4	4
Working as part of a team	4	4
Communicating with others in a group	4	4
Understanding and explaining how groups operate	3	4
Business and customer awareness	3	3
Problem solving	4	4
Applying mathematics to real-world problems	3	4
Being flexible and adapting to unfamiliar problems	3	3
Making and giving presentations	3	4
Writing reports	3	3
Confidence communicating complex mathematical ideas and results	3	3
Discussing your skills	3	3

Professional skills development

To investigate whether experiences in the module had any effect on professional skills development for students, a questionnaire on this specific aspect was administered at two key points within the module. The same questionnaire was used in both week 2 and week 11. Students were asked to rank their competence in 12 skills on a standard Likert scale with responses from 1–5, where 1 indicates 'no competence' and 5 indicates 'fully competent'. Students completed the form at the beginning of the session in week 2 and week 11 on paper forms. Forty forms were completed in both weeks, giving an overall response rate of 91%. The results of the responses are summarised in Table 4. As can be seen in Table 4, the skills covering presentations, group work and applying mathematics to real problems saw increases in median score between weeks 2 and 11. Obviously, these scores are student self-assessments and do not necessarily indicate genuine increased competence, but the focus on and exposure to these elements within the module have possibly influenced student confidence in these areas. Several key skills saw median scores remain unchanged, whereas no key skills saw a median score decrease.

Reflections from students

All students were asked to fill in feedback forms for the module, as is standard practice at the university. These forms were completed in the penultimate week of the module. A standard Likert scale is used, asking students to respond to 12 statements with either 'Strongly Agree', 'Agree', 'Disagree', 'Strongly Disagree' or 'Not Applicable'. Many of the 12 statements in this part of the feedback form relate to standard classroom issues, such as starting and finishing time of lectures and legibility of board writing, which are not particularly illuminating for the purposes of the current study.

The responses to 11 of the 12 statements provided a mean result comfortably in the range between 'Strongly Agree' and 'Agree'. The only response that did not replicate this was that to the statement 'Previous modules provided adequate background knowledge'. The mean response to this statement was in the range between 'Agree' and 'Disagree'. As discussed previously, the majority (35 of 44) of the students were studying Single Honours Mathematics and will have studied previous skills strand modules as part of their degree programme.

This interesting result from the feedback forms indicates that the final-year module is perceived as distinct in the strand and that students are aware they are required to tackle new challenges in this module. The need for outputs (reports and presentations) to be tailored to specific audiences in this module sets it apart from other skills strand modules. This particular feedback could indicate that students are aware of the emphasis on these elements of their work and the weighting given to these.

Thirty-six student feedback forms were received, giving a response rate of 82%. Students were also asked to specifically share any reflections they had on the module compared with their other mathematics modules. Student feedback focused on a few key themes – a desire for instructions on how to achieve higher grades, the different nature of the module to other final-year modules and skills development.

The use of grade-based marking criteria in this module is in contrast with most other modules at the same level, and the student feedback indicates that this had caused some students to feel that there was not enough transparency with allocation of marks. Five separate comments were made in this area. One student commented that 'the questions were often vague and it was unclear what needed to be done to achieve a good mark'.

Three student comments made reference to the impression that this module is very different from other modules on offer in the department. One commented that the module had a 'different structure to the usual modules which is interesting and enjoyable. Challenging but worthwhile'.

Four of the comments highlighted the work involved in the various group projects and the investment required outside of lab sessions. One student commented that the module 'takes a lot of time outside of assigned lectures but worth it as it's been really interesting and different to the other modules available'. Another student seemed to find the time investment a burden – 'the group projects require a lot of work to be done outside the assigned lecture slots which puts pressure on the other modules being taken'.

The open-ended nature of the tasks seemed to be the focus of several student comments. Four comments highlighted this aspect of the module. One student remarked that 'the project asked us to effectively find something interesting with radar which I thought was way too vague and difficult'. However, students seemed to have different views of the final project, with one student seeming to appreciate the freedom of the task – 'There isn't always a set question to answer and we must find a meaningful problem to solve that we can benefit from in some way'.

There were several student comments that indicated an observation of how general problem-solving skills gained from studying mathematics in higher education were utilised in the module tasks. One student commented that

> Mathematics in industry often involves very few equations and a high level of logic and understanding of the particular field. Every role is very different, using a different area of mathematics. However, they all use the same logical systematic approach to solve problems that have no exact solution.

Some students also seemed to comprehend the importance of the accuracy and communication of mathematical work in industry. As one student commented,

> In the real world it is necessary for the mathematician to competent at and capable of setting up and solving problems within their subject correctly since they produce solutions that are relied upon by others.

Lecturer reflections

Lecturer feedback was collected by an end-of-module evaluation form in which the lecturer was asked to reflect on how the module was run and how the module activities were received by students. One of the main points covered in lecturer feedback was the role of the lecturer in this module when contrasted with more traditional modules. The differences are especially evident in the third group project where students are directed towards the domain expert for technical advice and the module lecturer in this instance became a motivational figure offering encouragement and prompting groups to think about wider issues around group management.

Another point raised in lecturer feedback was the importance of organisation and the clarity of messages to students. A module like this requires a great deal of advance preparation and the various deadlines, briefing documents and output expectations must be clearly communicated. As the module is assessed by reports, essays and presentations, the use of grade-based marking criteria must also be clearly explained to students, and it was felt that a class exercise early in the module discussing the marking of sample reports helped inform students about how this would be used. The lecturer felt that the grade-based criteria still presented some challenges as many students in mathematics will have experience of receiving marking schemes that identify each individual mark.

The lecturer notes that it can be difficult leading a module like this at first, particularly when students are struggling with a project as some groups did with the third project here. The instinct is for the lecturer to immediately offer assistance. In this module, the difficulty is in recognising that the struggle is necessary and part of the intended learning.

In the third project, students have a resource in the domain expert emails that can be used, but the intention is that groups will persevere and perhaps solve problems themselves. In this case, the lecturer can only really remind students about the email resource and ask them to consider the management of the task. In particular, the lecturer can stimulate group discussion on whether there is time to consider the particular issue given the current state of the project or whether an email could help keep the project moving, despite the cost. In this scenario, the lecturer observed that some groups were hesitant about sending emails, even when little progress had been made for an entire week. This was brought to the attention of the relevant group by the lecturer, and again these groups were asked to consider the general progress of the project.

Conclusion

The feedback from students in written comments and their self-assessments with professional skills raise interesting points for consideration. Whereas some professional skills saw increases in median score over the course of the module, a greater number of the skills saw median scores in week 11 remain the same as in week 2. Further work could investigate possible reasons for this. It is certainly the case that students are tackling assignments of a very different nature to those in other modules. Students are also receiving critique on aspects of their work that are not limited to the accuracy of mathematical work or calculations (for example, the suitability of a written argument for an intended audience or the quality of reflections on group projects). A lack of exposure to these aspects of conducting and presenting mathematical work, along with the initial critique of these elements, could perhaps affect the confidence of students on the module.

The client project had a particular set of questions to consider but still allowed the groups flexibility in deciding on which aspects of the data to investigate. This project can thus be categorised as a guided inquiry in the terminology of Banchi and Bell (2008). The client project also invited students to consider wider recommendations for the client based on mathematical work that they might conduct.

The third group project (which can be categorised as an open inquiry task) has been seen to foster some elements of appreciative inquiry amongst students on the basis of the individual student reflections. The freedom in setting their own research question and then planning and carrying out the investigation allowed some students to develop an appreciation for the direct relevance of their mathematical work to problems facing businesses and organisations.

While there is evidence here that some students found the freedom in the group projects empowering, for others the lack of specific tasks and the phased inquiry-based approach proved to be a difficult shift from expectations established in their previous educational experiences with mathematics. This can be a difficult transition for both students and staff. UKCES (2008) notes that modules with an inquiry-based approach often require shifts from traditional didactic instructional approaches to teaching methods built around facilitation and coaching. As observed in the feedback, some students would have felt more comfortable to be set a problem with more explicit (and limited) goals or objectives. Instead they were faced with projects that had increasingly flexible objectives and thus greater scope for genuine investigation and discovery.

This module forms part of a strand of skills modules, and while all of these modules at lower levels require students to give presentations and work in groups, it should be noted that this final-year module has the specific slant on professional skills and carrying out a mathematical task for a particular business or organisation with its own agenda and interests. This could be another possible reason why students still feel slightly wary of their competence with many of these skills, which they could be exploring for the first time.

Exposure to the tasks in the module provides students with opportunities to build and explore their professional skills and to form an appreciation for the management of tasks when problem solving. The tasks here also encourage students to view problems in a wider context and to acknowledge businesses or other clients and their associated priorities. This aspect of the design of the module, as suggested by Cranmer (2006), has provided students with an appreciation for the projects as they are set and assessed in collaboration with individuals working in industry.

The challenge for the lecturer in this type of module is to prepare students for the shift in learning outcomes and assessment. As discussed previously, these elements necessarily have to be different in this type of module, and clarifying expectations with students is essential. Class exercises such as the grading of sample reports can help with this endeavour, although there can be a delicate balance between time spent with initial exercises on clarifying expectations and time devoted in class to the actual project work.

Another interesting discussion point for further investigation is the stage at which modules focusing on professional skills are offered to students. A module like the final-year module in this case study relies on student maturity to engage fully with the unfamiliar aspects of the assessment and structure. However, by only introducing this professional and business slant to the strand in the final year, students can feel that this breaks with their established expectations of mathematics at university (as observed in the feedback form responses). An alternative model could perhaps be explored where the various dimensions of professional skills for mathematics are embedded at an earlier stage.

The study could be extended to consider the various modules in the strand and whether student views change over the course of their degree programmes. Semi-structured interviews or focus groups with students across the modules in the strand could also provide a deeper understanding of student views concerning skills development. It could also be useful to administer the questionnaire in this study across the various modules in the strand to monitor skills development over the course of the entire degree programme.

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