Professional skills development for mathematics undergraduates

RUSSELL, Ewan and ROWLETT, Peter <http://orcid.org/0000-0003-1917-7458>

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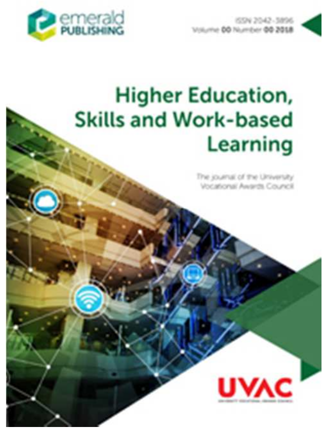

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Title

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Purpose

To describe the design and development of a final year undergraduate mathematics module designed to address professional skills development at a UK university, including via input to curriculum and assessment from employers. To investigate student acquisition of skills from this module.

Design/methodology/approach

Literature on skills development in mathematics informs module design and development. Students optionally completed Likert-style competency questionnaires before and after the taught module content, and reflected on skills development via an end of module questionnaire. Data collection took place over three academic years.

Findings

Several key competencies exhibit median increases over the course of the module in each academic year, indicating a perceived skills development. Problem solving and presentation skills are particularly highlighted.

Research limitations/implications

Numbers of students were small, though the study is repeated with three different cohorts. Some students study mathematics jointly with another discipline and hence may have experience in skills development from the other subject.

Practical implications

This study indicates that innovations in teaching style and assessment in mathematics modules can enhance student confidence and competence with key professional skills.

Originality/value

Undergraduate modules in mathematics which have a focus on professional skills development are still fairly rare in UK universities. Often such modules do not embed the professional skills development activities with subject specific technical tasks and projects as this module does. There are few formal studies of the effectiveness of this style of module, especially longitudinal studies covering several academic years.

1. Introduction

A mathematics degree is rightly concerned with developing students' knowledge and skills in mathematical topics. It is also necessary to ensure the development of professional skills – "what is left after the facts have been forgotten" (Beevers and Paterson, 2002; p. 51) – which are needed by professional mathematicians to "use their knowledge effectively" (Challis et al., 2002; p. 80). The need for such development is clear. A recent UK Government review found "a large body of evidence" pointing towards employer dissatisfaction with Science, Technology, Engineering and Mathematics (STEM) graduates in respect of 'work ready' skills (Wakeham, 2016; p. 3), and there are reports that mathematics students are increasingly concerned that their degree should equip them with skills for graduate employment (see, for example, Waldock, 2017).

This paper describes the design and development of a final year undergraduate mathematics module at a UK university which aims to address professional skills. The module was designed and delivered in its first year by the second author. The first author then took over teaching the module and made further developments, including input to curriculum and assessment from employers. To investigate student acquisition of skills from this module, students were asked to complete a competency questionnaire before and after the taught content, and to reflect on their skills development via an end of module questionnaire. Data collection took place over three academic years. This paper is organised as follows. The initial design decisions and later developments are described, including influences from practice-based literature. The evaluation method and results are outlined, followed by discussion of findings.

Undergraduate modules in mathematics which have a focus on professional skills development are relatively rare in UK universities. Sometimes, such modules offer skills development outside mathematical context, whereas the module described in this paper embeds the professional skills development activities within subject-specific technical tasks and projects. For example, Codling (2017) describes a three-year employability module implemented as a 'zero-credit' addition to the taught programme through a desire not to remove any mathematical content from the main degree. Teaching practice in undergraduate mathematics is relatively under-researched in general (Speer, et al., 2010). Though there are some informal or small-scale evaluations of the effectiveness of this style of module (Waldock and Rowlett, 2012; Rowlett and Waldock, 2017), there are no longitudinal studies covering multiple cohorts. The present study is situated in a UK context, but the findings will have wider applicability. The mathematics curriculum is generally similar internationally and the skills wanted by large employers transcend national boundaries; see, for example, discussion by Deloitte Access Economics (2014) of "soft skills" desired by employers of STEM graduates in Australia

(p. 76). It is hoped that the approach taken here could easily be adapted to other disciplines; indeed, the discussion here does not focus on the mathematical detail.

2. Module design and first year of operation

The module in this study was developed to address professional skills development in the final year of a UK undergraduate mathematics degree, partly in response to a university-wide employability agenda. A range of professional literature was consulted to inform module design and this is discussed in this section; though note that much of the module design is also consistent with recommendations from employability research (e.g. Knight and Yorke, 2004). A major study of over 400 mathematics graduates 2.5 years after graduation was completed by Inglis et al. (2012). They found few believed that undergraduate study had developed their communication and team-working skills, or their "ability to apply mathematics to the real world" (p. 18). These skills were widely regarded as substantially important in the workplace but underdeveloped during mathematical study (p. 27). Consequently, the key skills identified for the new module to develop were problem-solving, team-working and communication skills.

The module is a one semester, final year module first offered to students in the 2012/13 academic year. It contributes 15 credits from 120 in the final year. It has no pre-, post- or co-requisites. The intended learning outcomes were written to focus on specific developments rather than use generic terms. So rather than simply "problem-solving skills", the module was designed to develop "the ability to select techniques", "apply mathematical knowledge to real-world phenomena" and work "in depth over an extended period of time". The communication skills learning outcomes called for results to be communicated "to audiences of differing technical ability via different methods". The group work outcomes included that students would "appreciate how groups operate".

Undergraduate mathematics is typically taught via traditional 'chalk and talk' lecturing (Duah, et al., 2014; p. 554), while assessment is "overwhelmingly" dominated by the closed book examination (Iannone and Simpson, 2014; p. 71). Hibberd (2005) believes that these methods of teaching and assessment might be "strong" for "the attainment of knowledge" but they make more limited contributions to skills development (p. 6). Waldock (2011) argues that alternative methods of assessment can encourage skills development alongside mathematical content in a way that traditional assessment methods do not.

It seemed appropriate, then, that the module would use alternative teaching and assessment methods that target communication and team-working skills, developing these in a mathematical context which explores applications to professional scenarios.

However, it is not always clear to students that such skills development or teaching and assessment based around communication and team-working should form part of their curriculum (see, for example, MacBean, et al., 2001). Employability development requires students who are aware of what they are learning and why (Knight and Yorke, 2003). In addition, the prevalence of certain teaching and assessment methods earlier in the course leads to an implicit agreement that can raise barriers to the introduction of alternative teaching approaches (Duah, et al., 2014; p. 554). Effort was needed, then, to convince students that the purpose of the module and use of non-standard teaching methods were worthwhile.

An exercise was designed for the first class where students worked in groups over a 45-minute period to develop a short presentation to be given to the whole cohort based on a reading sample provided. The samples comprised excerpts relevant to the module theme, including from a report on the Destination of Leavers of Higher Education (DLHE) survey and reports from groups such as the Confederation of British Industry (CBI), as well as parts of Inglis, et al. (2012) and some articles on what mathematicians do in industry (e.g. Budd, 2008). This had the effect that each group presented different parts of an argument for running the module to the whole cohort during the first session. Subsequent sessions were largely focused around the group project activities.

The module was planned to be activity-based, with learning and assessment taking place through student-led activities and project work. Three summative group tasks were designed to address particular intended learning outcomes.

1. A short time-scale, low stakes problem-solving task of approximately two hours' duration. Students were presented with an urgent scenario and asked to find a mathematical solution, to be communicated clearly via written reports for mathematical and non-mathematical ('client') audiences. This was designed to encourage awareness among each group of the strengths of its members, in order to assist groups in organising themselves more effectively for the higher-stakes group tasks to follow.
2. An in-depth project of three weeks' duration, in which students worked in groups to address a specific task from a client. This was supported by directed reading. The solution was communicated to mathematical and non-mathematical (client) audiences via reports. In the first year, the client was fictional due to practical constraints (more on employer involvement later in the article).
3. An in-depth project of six weeks' duration, in which groups proposed and developed a research topic based on real-world data. The data were from a public source, though this is another opportunity for potential employer input. Employer engagement was provided in the first year via a talk by an alumnus employed in a data analysis role. Findings were communicated to mathematical

and non-mathematical (public) audiences via reports, a presentation and an audio media report suitable for public radio or a podcast.

Some thought was required as to the mathematical topic to be studied. Hibberd (2002) recommends that project work should avoid difficult new mathematics, for “a realistic expectation” that students will be able to engage with the skills development (p. 163). Chadwick, et al. (2012) suggest that work-related learning requires realism, though this will necessarily be moderated by practical constraints. They suggest authenticity can be provided by employer involvement. Employer input into the curriculum has been shown to have a positive effect on employability prospects (Mason, Williams and Cranmer, 2009). However, direct employer engagement is resource-intensive and not always felt to be crucial; for example, Benjamin et al. (2012) created a shared resource bank of industrially-inspired projects for use in this kind of module where access to employers is not available.

Challis et al. (2002) recommend teaching students how groups operate, saying "transferable skills must be taught explicitly as are all other aspects of the course: it is not sufficient to put students into groups and ask them to undertake tasks" (p. 89). For this reason, the summative group work was preceded by a lecture, group discussion and reflection on a formative small-group exercise.

Groups were kept deliberately large (8 or 9 students) so that tasks must be subdivided and to increase the difficulty of dynamics which the group must manage. One issue is how to assign students to groups. Self-selection may be preferred by students as it avoids “friction within a group” (MacBean, et al., 2001; p. 8). However, this is seen as less realistic by employers (Chadwick et al., 2012; p. 49). Lecturer- or randomly-assigned groups may be frustrating for students (MacBean, et al., 2001; p. 9). Here, a method was used in which students form small groups, which are then paired to form larger groups using information gathered during reflection on the formative small-group exercise. This method is described in detail by Author2 (2013).

An awkward issue in group work is that of uneven contribution and student perception of unfair treatment if the same mark is given to all in a group (Iannone and Simpson, 2012). Hibberd (2002) recommends assigning explicit marks for group management and peer assessment of individual contribution. Lowndes and Berry (2003) recommend having groups operate a committee structure which keeps formal minutes, indicating actions and progress identifiable with each team member.

In previous experience of group projects (Author2, 2011), minutes of group meetings were used to monitor group activities without peer assessment of contribution. Students were encouraged to bring uneven contribution, evidenced by minutes, to the attention of teaching staff. The use of minutes was found in the evaluation of that teaching to be helpful in organising the work but ineffective in detecting uneven contribution. The motivation for not using peer assessment in that module was due to concern about asking students to complete additional work that did not contribute to module learning outcomes. Here, a module learning outcome was written to include reflection, in order to make available the benefits of reflective activity (Waldock, 2010). For this new module, minutes of group meetings were used as a tool for groups to attempt to assign and monitor activities to individuals, and a group management mark was derived from these. In addition, peer assessment of contribution was used to modify the group mark for individual group members in group projects 2 and 3.

As well as adjustments to group marks, some individual assignments were included in the module design in order to further take account of individual differences. Three reflective essays developed and assessed students' understanding of their skills, while two mathematical assignments assessed individual comprehension of group topics. Particularly in group project 2, assigning an individual piece of work on the same topic was felt to bring high risk of collusion. To mitigate this risk, a partially-automated approach to this individual assignment was used (see Author2, 2014, for more details).

3. Changes made for the 2013/14 academic year

Following the introduction of the module in the 2012/13 academic year, several opportunities were explored to enhance the delivery and content of the module in 2013/14. In particular, alumni and industrial partners were contacted to contribute ideas for the module. It was hoped that these individuals could provide input on the module activities to ensure that these were more directly relevant to current employer expectations. By involving these individuals in the module enhancement, it was envisioned that students could gain valuable experiences of using mathematics to tackle genuine problems from a workplace.

Employer contacts were extremely enthusiastic and helped to design two of the three group projects for the module. The first of these was in data analytics and required the students to carry out an analysis of website traffic data. The analysis had to be presented for a client audience where it could not be assumed that the client had any sophisticated mathematical knowledge. Students had to make convincing recommendations for marketing an upcoming sale based on this analysis of customer website data. In the assessed outputs for this project there was a significant focus on whether the presentation and content of the materials were appropriate for the client audience. The client was directly involved in the assessment of the project outputs and client feedback was provided to students.

The second of these projects was designed in collaboration with an industrial partner who is an expert in marine radar. Radar data were recorded from two radars in Milford Haven on two different dates and the raw files were made available to students. The industrial partner gave a briefing on marine radar and provided instructions on how to access and use the data. The groups then had to decide on an appropriate research question to carry out for six weeks based on this data. The final outputs for this project were a technical report and a short talk aimed at a public audience. It was hoped that the different presentation styles required for the report and public talk would challenge the students to create outputs documenting mathematical work which are appropriate for a given target audience.

The marine radar project incorporated an additional dimension in that the students did not have a great deal of interaction with the domain expert in person. This was intentional (and necessary as the domain expert had a busy schedule and could not attend all classes). The industrial partner delivered an introductory session but it was decided that subsequent contact should be via email. Due to the unfamiliar topic area, contact with the domain expert in this format would be required by all groups at some point. A costing procedure was introduced whereby the groups would be allocated five ‘free’ emails to the domain expert each but for any additional emails after this there would be a cost involved. After much discussion between the module leader and the domain expert, it was decided that the cost should be in the form of impact on the deadline for the final report. Specifically, the deadline for the final report would move one day earlier for each additional email used. It was hoped that this costing procedure would make the groups think about their questions and also that it might encourage the groups to persevere with problems and try alternative approaches to tasks.

4. Methodology

Data were collected in the 2013/14, 2015/16 and 2016/17 academic years via student questionnaires. The primary focus of these questionnaires was for students to rate their competence in twelve key professional skills which are directly linked to the intended learning outcomes. A 5-point Likert-style scale was used with 1 indicating ‘no competence’ and 5 indicating ‘fully competent’. The timetabled activity for the module consists of one three-hour lab session per week. In 2013/14, the questionnaire was first distributed to students at the beginning of the second lab session. The same questionnaire was distributed to students at the end of the module. The twelve competencies (as listed on the questionnaire) were

1. Self management
2. Working as part of a team
3. Communicating with others in a group
4. Understanding and explaining how groups operate
5. Business and customer awareness
6. Problem solving
7. Applying maths to real world problems
8. Being flexible and adapting to unfamiliar problems

9. Making and giving presentations
10. Writing reports
11. Confidence communicating complex mathematical results to audiences of differing mathematical abilities
12. Discussing your skills.

Students were made aware (in the first week of the module) that the module has a focus on skills which are desirable in employment. It was explained to students at the beginning of the second lab session that the initial questionnaire aimed to identify their perception of their current level of competence in twelve of these key areas as part of a study on skills acquisition. Students were encouraged to be as honest as possible and were told that the questionnaires should be completed individually. The questionnaires were completed in silence at the start of this second lab session. By holding the initial questionnaire at the beginning of the session, it was hoped that the students would be focused on this initial task and answer thoughtfully.

The second questionnaire was administered at the end of the module in the hope that there would be a sufficient time for students to develop an awareness of their own level of competence with the twelve core skills. The timing of the second questionnaire made it unlikely that students would recall how they responded to the first questionnaire.

The second questionnaire was administered in the final (2013/14) or penultimate (2015/16 and 2016/17) week of the module. Students give presentations on one of the group projects in the final lab session and preparation for this negatively affected engagement with the questionnaire in 2013/14. This is also the reason why no data from 2014/15 is available.

5. Analysis of student questionnaires

Forty-eight questionnaires were returned in the 2013/14 academic year for a response rate of 74%. The respective numbers for 2015/16 and 2016/17 are thirty-five (92% response rate) and thirty-nine (89% response rate). A comparison of the median scores for the competency self-assessments in the three academic years is presented in table 1.

TABLE 1 HERE

As can be seen from table 1, no competencies showed a decrease in median from the first observation to the second and there were several median increases observed in each of the three academic years. Two of the competencies ('applying maths to real world problems' and 'making and giving presentations') saw median increases in each of the three academic years observed.

A non-parametric formal statistical test was used to identify whether any of the changes observed in the twelve key competencies between the first and second observations are statistically significant. The data here are ordinal and so the Kruskal-Wallis Test is appropriate. The results of the Kruskal-Wallis Test are presented in table 2.

TABLE 2 HERE

Table 2 shows that seven of the twelve key competency areas exhibited statistically significant results when comparing data from the two questionnaires using the Kruskal-Wallis Test in 2013/14. Explicitly, the results covering “business and customer awareness” and “problem solving” were statistically significant with $p<0.001$. The results covering “self management” and “making and giving presentations” were statistically significant with $p<0.01$, while the results covering “applying maths to real world problems”, “being flexible and adapting to unfamiliar problems” and “writing reports” were statistically significant with $p<0.05$.

In 2015/16, the results covering "writing reports" was statistically significant with $p<0.05$.

In 2016/17, the results covering "communicating with others in a group" were statistically significant with $p<0.01$. In this academic year, the results covering "self management", "understanding and explaining how groups operate" and "being flexible and adapting to unfamiliar problems" were statistically significant with $p<0.05$.

6. Feedback from undergraduate students

Undergraduate students were encouraged to reflect on their experiences in the module. In particular students were asked in the final week of the module to give their opinions and reflections on mathematics at university compared to mathematics in the real world. Some of the major themes from these reflections are detailed in this section. For this reflection, many students used their recent experience working on the marine radar project which simulated working for a mathematical consultancy. Some of the comments relating to this final group project are given below.

‘I think only having 5 emails per group was actually a good idea since it stopped us giving up on the problem and asking for help when we could solve it ourselves. In addition, it enabled us to experience what it would be like working for a business and to decide when it would be appropriate to contact the client.’

‘I think our group should have asked more questions at the beginning (of the marine radar project) to gain a greater understanding, which would enable us to meet the demands of our client more closely and add more depth to our research.’

‘Although originally I thought the project was unrealistic and that it was unfair to leave the groups with very little guidance, I think that it was a valuable learning experience that enabled me to choose the method for working and the way in which to approach it.’

Some students chose to consider the wider comparisons of their work in the module contrasted with their experiences in more traditional mathematics modules:

‘In my current work, in Partial Differential Equations, I may have a set problem with a set method to solve it, lecture notes to check and examples to compare. This is obviously conducive to the learning environment where we are being taught particular concepts in mathematics, however, isn’t necessarily reflective of how mathematicians work in the real world... If a problem arises that hasn’t been met before it is likely that it will be up to you alone to find an answer. This could require extensive research, or trying many different methods, something which university struggles to simulate as it doesn’t quite fit in the structure of education.’

‘In the real world problems need to be simplified and logically pulled apart so known approaches can be applied’

‘The solution to a problem is not always obvious; there is no textbook to refer to for the specific method or theorem required, and there is no single correct solution. Instead, there is a process of analysing the problem, finding the area of mathematics that may be useful to apply to the situation, deciding on a suitable solution and how to then convey the complicated mathematics to colleagues and bosses in an understandable way.'

'If students were not taught the basic theory (in earlier years of a maths degree), they would not have a full understanding of how real world models work. Therefore maths at university, despite originally seeming irrelevant to everyday work, contributes enormously to the comprehension of basic methods and theories, which in turn leads to the potential solving of real world problems.'

Another theme in these reflections was the consideration of intended audiences in the work for the module:

'Some maths problems in a business scenario require a solution that provides both a suitable service to the customers while being financially viable for the company. Solutions of this type can't necessarily be obtained by simply applying formulas and instead require situational experience.'

'When dealing with maths in the context of business, there is often no single solution to a problem… The solution is highly dependent both on the aims of the person setting the problem and on the opinions of the problem solver.'

In each academic year approximately a dozen comments reflected an understanding of the differences between the mathematics presented in taught modules and the approaches required in tackling mathematical problems in a business or industrial context. It is also encouraging that most students indicated that they value the mathematical knowledge in their more traditional modules and that they see how this background knowledge is essential as part of a toolkit to tackle unstructured real world problems.

While many students conveyed that they had learned something from their experiences in the module, it is inevitable that some students found the experience of working on unstructured problems with the pressures of a variety of outputs for intended audiences too radical a shift from the traditional mathematics modules to which they had become accustomed. This is summed up in the comment below.

"With project two when we found a problem we simply asked the appropriate person for help, as we might expect to in a real world scenario, so we can easily move on to reach our goal within the task. This meant the project (project 2) ran much smoother and felt much more realistic."

7. Discussion of the results

It is clear from the data analysis that the module has had an impact on students. In particular, students' assessments of their own skills over the course of the module exhibited some positive changes. The median scores for several of the twelve competencies returned increases in the second self-assessment compared with the first.

In this module the intended audience for mathematical work is an important consideration. In particular, student groups are required to not only carry out a mathematical investigation in each of the project tasks, but also allocate time to ensure that the project output is appropriate for the given audience. In line with Hibberd's suggestions, the focus on the skills development is aided by the mathematical content of the projects. In particular, no students in any of the academic years observed commented that the mathematics involved was too difficult. This allowed scope for every group member to become involved with the technical details of the projects.

Median increases were observed in each of the three academic years in the study for the competency specific to making and giving presentations, indicating that this emphasis in the module is having a positive effect on students. The skill of tailoring a presentation to a specific target audience is unique in the degree programme. This is a feature which alumni and industrial partners have commented is essential in preparing students for the world of graduate employment.

The Kruskal-Wallis Test results illustrate some key skill areas where student experiences of the module seem to consistently and positively affecting confidence. Explicitly, the competencies focusing on the development of problem-solving strategies and self-management showed statistically significant results in two of the three academic years in the study, suggesting that experiences in the module are contributing to development in these areas.

The results from 2016/17 indicate that students in this cohort were more confident in understanding group work from their experiences in the module as two of the key competencies relating specifically to this theme showed statistically significant changes in 2016/17. This is particularly interesting as at least 80% of the students enrolled on the module in this academic year had previously studied modules involving group work on the degree programme. The results from 2016/17 indicate that the students are building on their past experiences of team work and group projects in this module.

Limitations and suggestions for future research

The data here are reliant on self-assessments made by students about their own level of competence and this should be taken into account when attempting to interpret the results. The attainment of students in this module could potentially influence their self-assessment of skills development, although it should be noted that the second questionnaire was completed before the final group project marks and the final individual assignment marks were determined. This meant that 40% of the overall module mark was unknown to students at the time when they completed the second questionnaire.

It should also be noted that the focus in this module on the appropriateness of the presentation of mathematics, and not mathematical accuracy alone, initially cost many groups marks in assessed work. It was observed in most academic years that the importance of both elements only registers with students following feedback from the first two assessments. This experience could give students the impression that they are not performing well, which could potentially influence their self-assessment on the second questionnaire.

The module is an important and popular part of the mathematics degree programmes, attracting a mean of fifty students per year. Future work should look in greater detail at the background of students on the module and their prior exposure to skills development. As several students are studying Combined Honours degrees (i.e. mathematics alongside another discipline), their educational experiences in their other academic discipline could account for some of the results observed in this particular study and the variation in the competencies which saw statistically significant increases.

While past studies have observed positive effects of a variety of one-off or single cohort skills interventions, this longitudinal study has formally investigated professional skills development over three academic years. This novel study has shown that increased student confidence in key skills areas can be observed consistently in a mathematics module which explicitly embeds subject-specific tasks. As observed in this study, variation in the past experiences of each cohort can present corresponding variations in the specific skill areas where students are aware of these changes. Focus groups in future years could be set up to formally investigate the effect of past experiences on perception of specific skills development. The work here could also be extended to consider the graduate outcomes and destinations for students who have studied this module as part of their degree. In particular, it could be useful to consider the reflections of alumni on the relevance of their experiences in this module for their skills and career development.

8. Conclusion

This study has demonstrated a strategy for embedding professional skills in a mathematics module which has been successful in many of the intended outcomes. In line with the work of MacBean et al., it was clear in each year that some students are still not fully convinced that professional skills should be the main focus of a module in the mathematics curriculum and some never fully accept the contrast between this and their other mathematics modules.

The views of Chadwick et al. are also supported in the study as the direct employer involvement added a relevance to the project work for students, as is evidenced in the feedback. Student comments also indicate an appreciation for the range of mathematical problems encountered in industry, based on their experiences with the projects in the module. Feedback also indicates that students acknowledge the role of university mathematics when mathematicians in industry tackle these problems.

Past initiatives or attempts to embed professional skills development within mathematics modules have taken a variety of different approaches. Examples of this include the incorporation of CV and application letter writing tasks as part of the assessment within modules or the addition of zero-credit skills modules to the curriculum (Rowlett and Waldock, 2017). These can seem detached from subject content, even when they form assessed components within a mathematics module, as they are not explicitly linked to rich mathematical tasks. The module in this study encourages skills development alongside three very different mathematical projects. The feedback obtained in this study indicates that students appreciate the additional considerations which are required when completing a piece of mathematical work for a specific audience, and come to view this as an important part of their development as mathematicians.

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	2013/14		2015/16		2016/17	
Competency	Median (Questionnaire 1)	Median (Questionnaire 2)	Median (Questionnaire 1)	Median (Questionnaire 2)	Median (Questionnaire 1)	Median (Questionnaire 2)
Self management	4	4	4	4	4	4
Working as part of a team	4	4	4	4	4	4
Communicating with others in a group	4	4	4	4	4	4
Understanding and explaining how groups operate	4	4	4	4	3	4
Business and customer awareness	3	4	3	4	3	3
Problem solving	4	4	4	4	4	4
Applying maths to real world problems	3	4	3	4	3	4
Being flexible and adapting to unfamiliar problems	4	4	3	4	3	3
Making and giving presentations	3	4	3	4	3	4
Writing reports	3	4	3	3	3	3
Confidence communicating complex mathematical results to audiences of differing mathematical abilities	3	4	3	3	3	3
Discussing your skills	3	4	3	4	3	3

Competency	p-value 2013/14	p-value 2015/16	p-value 2016/17
Self management	0.005028	0.1336	0.01447
Working as part of a team	0.05123	0.4991	0.07116
Communicating with others in a group	0.284	0.4816	0.008136
Understanding and explaining how groups operate	0.7628	0.4372	0.04509
Business and customer awareness	0.0001199	0.132	0.523
Problem solving	0.0003473	0.4981	0.241
Applying maths to real world problems	0.01094	0.1661	0.7936
Being flexible and adapting to unfamiliar problems	0.01464	0.2963	0.0189
Making and giving presentations	0.002085	0.3167	0.1667
Writing reports	0.01198	0.02718	0.4831
Confidence communicating complex mathematical results to audiences of differing mathematical abilities	0.3712	0.581	0.1231
Discussing your skills	0.1246	0.8721	0.1771