Students' perceptions of assessment practices used in a Business and Industrial Mathematics module

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Business and Industrial Mathematics at the University of Salford is a 20-credit second-year module in the mathematics undergraduate degree. It spans two semesters. Its novelty lies in the diversity of assessments and delivery modes used, such as open-ended problems, problem solving, group work, presentations, report writing, employer seminars and professional studies. This study aims to explore and present students' perceptions of these various assessments and assessment practices.

Keywords: assessment practices, applied mathematics, teamwork, professionalism, brainstorming, problem solving

Overview

In an effort to reflect the modern workplace for mathematicians, the Business and Industrial Mathematics module offers a breath of assessment strategies. The module aims to prepare students for employment and thus, it presents ways in which students are expected to use their mathematical knowledge in their future careers. The module also assesses students for work related skills (Chadwick 2011; Chadwick, Sandiford and Percy 2011), and the students' responses to the module have been recorded as part of the Mapping University Mathematics Assessment Practices (MUMAP) project which mapped out existing mathematics undergraduate assessment procedures (Chadwick and Radu, 2012).Throughout the module, guest speakers give seminars on a spectrum of mathematical applications used in industry, discuss the real world context and give students insights into the world of work and the ways mathematics may be used in their jobs. These speakers represent a range of different employment sectors, such as Defence Science Technology Laboratory (DSTL), Computer Management Systems (CMS) intelligent banking, Manchester Medical Academic Health Sciences, National Health Service (NHS), International Business Machines corporation (IBM), an expert court case witness, Institute of Mathematics and its Applications (IMA) and the Sellafield Operations Research (OR) group. The speakers also describe the structure and profile of the companies they work for and present the career paths students might pursue. The module attempts to address features playing an important role in the workforce, such as teamwork, problem solving and professionalism.

Module structure

This is a new module not existing before, devised as part of the newly introduced B.Sc. Mathematics undergraduate degree programme at the University of Salford. The module scheme has four different assessments with weightings 50%, 20%, 20% and 10% respectively. The first assessment centres on teamwork. Groups of four are

created and each team member is given a different role: chair, secretary, technical coordinator and task coordinator. Each group has to solve two work related problems and within each setting the team roles are changed so that students have the opportunity to experience different functions. Each team meets weekly for 30 minutes with an academic adviser whose tasks include observing and noting the team members' interaction, and how well the students adapt to the given roles and subsequent role changes. The team's deliverables include: a report detailing a mathematical model (60%), a minutes' book (10%), a project plan (10%) and a presentation (20%). The latter is given in front of an audience of industrialists and they offer constructive feedback and rank the talks.

The second assessment centres on class-based brainstorming. The module leader starts the discussion on the whiteboard by presenting some ideas on a given problem. Students are encouraged to contribute their own ideas and thoughts, and the whole class becomes engaged in this conversation. The module leader is separate from the academic adviser, and records contributions made by students through their ideas shared with the class and also on-going work presented in class to the module leader. The contribution (30% of total) is given a mark which is one of: full participation (100% mark); substantial contribution (60% mark); minor participation (40% mark); or no participation (0% mark). Each student has to create a final report, which constitutes the remaining seventy percent of the assignment. The third assessment targets students' problem-solving abilities. On a weekly basis, students tap into a database of games and puzzles. Upon choosing the one that most interests them, each student writes a report describing the game or puzzle. The report facilitates students' ability to describe the position, moves, tactics and strategies for a solution. This report represents seventy percent of this assignment's mark, while the rest is based on the students' involvement assessed at the weekly meetings by the module coordinator following the same marking scheme as for the second assignment. The fourth assessment focuses on professionalism. A set of questions (11 in total) of varying lengths are given to the students and require answering based upon information from the Institute of Mathematics and its Application (IMA) website, focusing particularly on professional development required for attaining the Chartered Mathematician (CMath) status. The answers are submitted in the form of a report, and the aim is to raise awareness about professional development for mathematicians.

Methodology

While these assessments are varied and contribute in various ways to enriching students' work-related skills, it is desirable to pinpoint the effectiveness of each assessment. A questionnaire was given to the second year undergraduate students who have taken the module. Students in both the first and second year were asked to consider which of the following work related attributes are deemed important and useful in a modern undergraduate mathematics degree. The list included items such as professional development, mathematical modelling, problem solving, workplace preparation, introduction to work practices, teamwork, and employer engagement. This list was developed in partnership with other academics on the programme and with industrial partners.

Students rated their answers on a five point Likert scale ranging from 'of no importance [or usefulness]' to 'extremely important [or useful]'. After rating the importance and usefulness of each attribute in a degree, the second year students from the Business and Industrial Mathematics module were asked to rate the effectiveness

of each of the four assessments in the module at developing these attributes, again on a five point Likert scale.

The questionnaire contained an open ended section, where students had the opportunity to share their views on the strengths and weaknesses of the module, on whether they would recommend the module to a friend, on what would they do differently in the module, and on whether they changed their professional development as a result of the module. Twenty-seven students completed the importance/usefulness quantitative questionnaire (16 first years and 11 second years). The 11 second year students evaluated the four different assessments on the module against those attributes and eight of them filled out responses to the qualitative part.

Data analysis

The quantitative analysis shows no significant differences between students' responses to importance and usefulness. Thus, the paper will only take into consideration the importance. There are significant differences between the perceived importance of the attributes ($F(6,182)=6.52$, $p<0.001$). Students consider problem solving and mathematical modelling as more important than professional attributes, such as professional development and introduction to workplace practices. Post-hoc t-tests (with Bonferroni corrections) show that problem solving is significantly more important that all attributes other than modelling and that modelling is significantly more important than employer engagement and introduction to workplace practices (all $ps<0.05$).

There were no significant differences between the first year and second year views of these attributes, even though the second years had more experience and had taken the module before, although the difference between the importance of employer engagement bordered significance ($t(25)=2.018$, $p=0.054$). Assessment 4 appears more effective (students were asked whether they considered it effective, rather than effectiveness being measured by a metric) at assessing the professional attributes of introducing workplace practices, employer engagement and workplace preparation, than the other three assessments. Assessment 4 was significantly worse at measuring mathematical modelling and problem solving than the other three (all $ps<0.001$) and worse than assessments 1 and 2 for measuring teamwork (all $p=0.028$ for both).

Students believe that the first three assessments present similar patterns of effectiveness across each attribute and that, in general they are better at assessing problem solving and modelling skills, than the work practice and employer engagement attributes. The pairwise t-tests with Bonferonni adjustment show that assessment 1 is seen as significantly more effective at measuring problem solving than work practices, employer engagement or workplace preparation. Likewise, assessment 2 is significantly more effective at measuring teamwork, modelling and problem solving than work practices or employer engagement and significantly more effective at measuring modelling and problem solving than workplace preparation. Assessment 3 is significantly more effective at measuring modelling and problem solving that work practices and employer engagement. Assessment 4 is significantly more effective at measuring work practices, employer engagement, workplace preparation and professional development than teamwork or modelling, and significantly more effective at measuring professional development than problem solving (all $ps<0.05$).

Data appears to suggest that skills, which are considered important such as problem solving and mathematical modelling, are being most effectively measured by

assessments 1-3. Likewise, the skills deemed less important, such as work practices and employer engagement, are being measured less effectively by the same three assessments. However, such skills are covered by the fourth assessment.

The qualitative data analysis presents students' perception on the module's strengths and weakness, benefits and views on its assessment strategies. The symbol '(n)' after each comment refers to the nth questionnaire sheet. Data shows that students believe that the Business and Industrial Mathematics module consolidates and improves team-building skills. It prepares and trains students to further develop their employability skills. The module's configuration encourages students to think about and plan for future mathematics related careers. It helps students to "learn how to work as a team and also how to apply maths skills to real life situations" (3). This is an ideal outcome of the course as students can go on to undertake mathematical as well as non-mathematical related jobs. Students also feel that the module "gets you thinking and perhaps planning for a future career" (7). The assignments' structure appears to help improve students' communication and team skills, such as report writing, keeping minutes and presentation skills. Students believe that the module also improves their mathematics skills. The students state that the course concepts were considered interesting to work with as these improve students' creativity and perception of mathematics as they learn "to use problem solving and intuition for the earlier assignments" (8). Furthermore, being part of a team improves students' organisational skills. Students enjoy that this module is not exam-based, as they believe such assessment structure offers more flexibility. They also mentioned the ease at which help and interaction is obtained from the lecturers.

The weaknesses of the module consist of students' failure to understand the relevance of the module for their future career path, the perceived difficulty to work as a team, and their desire to see more research. Students felt that not all the team members pulled their weight for the success of the project in an equal manner and this leads to experiencing "difficulty to work with a group of people who didn't put in as much effort as the others" (5). Ultimately, this leads to some difficulties in working together as a team. Students also expressed their desire to have more guidance in organising meetings or in taking minutes of meetings. Some students struggled to see the connection between the module and its relevance for future jobs and one even said the module does not present a challenge.

When asked whether or not they would recommend the Business and Industrial Mathematics module to a friend, students' perspectives appeared to be divided into four clusters. The first group of students believed the module gave good insights into what mathematics is. It provides interesting insights into mathematics and it is conducive to creating and implementing different solution paths to mathematics problems because "it was fascinating to see different methods developing to solve the problem" (5). Moreover, the module aims to create links with industry employees. Overall, the module offers an enjoyable mathematics experience and provides a clear and better understanding of mathematics. The second group of student stated that the module was well designed and had new fresh perspectives to assessment. The third group of students thought that the module has the ability to open one's horizons as "it also tells you the benefits of joining certain groups" (1). The last group of students stated that it helps students in improving their employability skills, such as communication, presentation or report writing.

If given the chance, students would alter the module slightly. They would welcome more independence in choosing their groups, would like to see more time invested in creating more enhanced professional projects, and would like to see

changes within the assessment structure. Only one respondent believed that the course is perfectly structured.

Students seemed to believe that the course is highly motivational. It helped them change their views about the nature of mathematics and even furthered their desire to join the IMA. The module contributed in increasing students' self-confidence in their mathematical abilities and in the team abilities: "now I am more confident in working with other people" (2). It made them consider embarking on graduate studies in mathematics as well as in math related careers. Overall, it made them feel more prepared.

Discussion

The quantitative data shows that students perceive the assessments they see most important and most useful as being most effective. In particular, assessments 1, 2 and 3 follow this trend. Assessment 4 seems to be more effective with the less important attributes. However, given that the students' views tend to be that the more important attributes are more mathematical (such a problem solving and modelling) and the less important are the direct employment and workplace attributes (introducing workplace practices and employer engagement), it suggests that the balance is about right. It does call in to question the extent to which employment related skills may be valued by students, though, even in a module designed to emphasise mathematics in the workplace.

The qualitative evaluation indicates direction for future development. Difficulties associated with students' disengagement in working with others in teams needs to be addressed. Comments indicate that greater help on how to perform work-related tasks such as writing reports, taking minutes, conducting meetings would be beneficial to students. The problems set to the students could be reconsidered, including increasing the level of difficulty, providing a research focus and further developing the work-related context. Overall, the module can be deemed successful in that the evaluation demonstrates the assessments were effective in developing the most important and useful attributes in the eyes of the students.

References

Chadwick, E. 2011. Assessing student teams developing mathematical models applied to business and industrial mathematics. *Presentation at the CETL-MSOR (Continuing Excellence in the Teaching and Learning of Mathematics, Statistics and Operational Research) conference,* University of Coventry.

Chadwick, E., K. Sandiford and D. Percy. 2011. Assessing student teams developing mathematical models applied to business and industrial mathematics. *MSOR Connections* 11(3): 22-24.

Chadwick, E. and O. Radu. 2012. Chapter 18: Evaluating Assessment Practices in a Business and Industrial Mathematics Module, In *Mapping University Assessment Practices,* ed. P. Iannone and A. Simpson, University of East Anglia publication: 75-82.