Developing Professional Skills in Mathematics Undergraduates : Three Years of Practice

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Setting the scene

- Mathematics graduates need transferable skills to "use their knowledge effectively" (Challis et al., 2002; p. 89) and it is "incumbent on us, as teachers, to help our students to learn and develop these skills" (p. 80).
- Employers report that graduates are technically competent but lack professional skills (Lowndes and Berry, 2003), and few recent graduates believe their degrees developed those skills that were "of substantial importance in the workplace" (Inglis, Croft and Matthews, 2012; p. 27).

Employability at Keele

- Key component of Distinctive Keele Curriculum (DKC).
- University push for staff to discuss and devote time to these skills.
- Keele University Skills Portfolio (KUSP) and ILM accreditation.

‘Professional Mathematics’

- 15 credit, one semester, optional module for final year mathematics and joint honours students with no pre-, post- or co-requisites, created for 2012/13 by PR and led since then by ER.
- The module intends to develop skills which are needed in employment or when undertaking a research degree but which “may not be developed by traditional mathematics teaching” (module document).

Module Design

Assessment for employability

- Traditional methods “strong” for “the attainment of knowledge” but make “more limited contributions to other elements” (Hibberd, 2005; p. 6).
- Waldock (2011) argues for developing graduate skills using alternative methods of assessment which encourage skills development alongside mathematical content.
- Hibberd (2002) recommends group project work for “a more active learning of mathematics, and an appreciation and acquisition of associated key skills” (p. 159).
- Professional Mathematics is, therefore, based around group projects.

Employer engagement

- Chadwick et al. (2012) suggest that work-related learning requires “realism”, though moderated by practical constraints, and recommend “authenticity” can be provided by “employer engagement” (p. 51).
- This may be because students value advice from industrial representatives over that from academics or careers staff (Chadwick, Sandiford and Percy, 2011).
- 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 where access to employers is not available.

Intended learning outcomes

- Problem-solving.
- Communication skills.
- Group work.

Intended learning outcomes

- Problem-solving:
  - The ability to **work in-depth** on a problem over an **extended period of time**;
  - Enhanced problem-solving skills, including the ability to apply mathematical knowledge in **real-world scenarios**.
- Communication skills:
  - Report writing skills;
  - Oral presentation skills;
  - Ability to communicate results **using different methods**;
  - Ability to communicate results **to audiences of differing mathematical abilities**.
- Group work:
  - Enhanced team working skills;
  - An appreciation of **how groups operate**.
- Ability to articulate graduate skills.

How much to use group projects?

- I decided on three aspects:
  - a project to learn about group working;
  - a project to learn about working for a client;
  - a project to learn about communicating to 'the public'.*

Non-group work

- Five individual assignments, to go along with the group projects (20% of the module mark).
  - Three reflective essays (300-500 words):
    - 'How our group operated and my part in it' (group project 1);
    - 'What the client wants' (group project 2);
    - 'The difference between mathematics at university and applying mathematics in the real world' (group project 3).
  - Two mathematical assignments, connected to group projects 2 and 3.
- Group management (via minutes of meetings) (10%).

Group Project 3

First Year

A project to learn about communicating to 'the public'

- During the Olympics and Paralympics, I ran a PHP script to save about 3 million public tweets.
- Offered students as much or as little of the data as they wanted (or could handle).
- They had to choose a question and design a project as a group (statistics, language processing, OR, graph theory (network theory), algorithm design, computational methods, etc. etc.).
- Assessment via mathematical report, public lecture (to staff), and via audio report (radio or podcast).

Student feedback – greater freedom over task

- "It was good to be given more freedom, but this was more than we ever had been before and took a while to come to terms with it all."
- “Felt that there was too much freedom in choosing our own project, this meant that we could easily put ourselves into trouble.”
- “Although others in my group disagree i felt it was quite good as it gave independence and that if we got stuck we had to figure it out ourselves rather than being guided to the answer by someone”.
- “It was good to be able to interpret the question in our own way. However, it was frustrating when we couldn't get told if we were doing it right.”
- “I felt we should have been given abit more guidance.”

Group Project 3

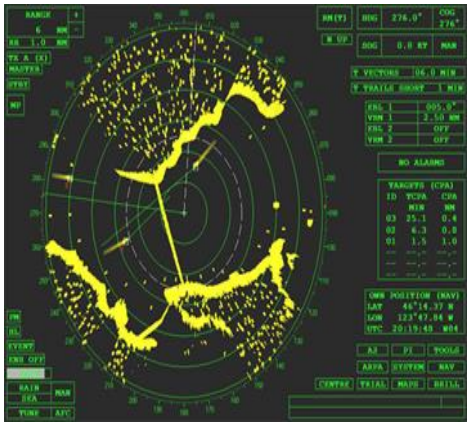
Second and Third Years

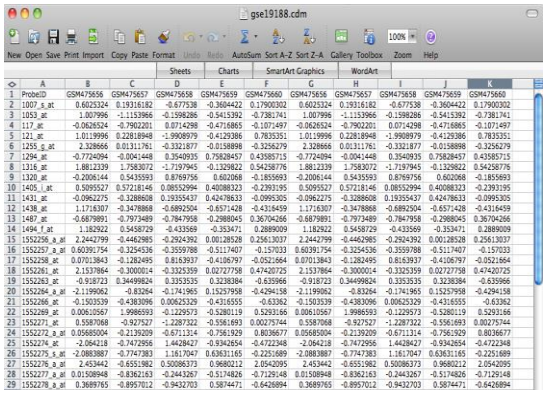
Project 3 - Aims

- To give students more independence and responsibility over their work.
- To replicate the experience of working for a mathematical consultancy.
- To provide experience of working with a domain expert in an unfamiliar topic area.

Project 3

- Raw data supplied by expert (industrial partner).
- Groups must decide on their own research question to investigate for 6 weeks.





Project 3

- Groups are able to contact domain expert via e mail.
- Costing Procedure:
  - five free e mails to expert;
  - each additional e mail brings the report deadline forward by one day.

Student Reactions

- Panic!
- Previous projects started with an initial skills discussion. Here, decision making went out the window.
- Time with expert used up asking about accessing the data.
- Had to be prompted on bigger issues e.g. scope and radar knowledge.

Expert Reflections

- Initial questions were unfocused (e.g. did not reference relevant frames of data).
- Most e mail questions easy to answer briefly. In these circumstances, a charge was not applied to the e mail response.
- Some e mails used just for checking accuracy of calculations.

Expert Reflections

- Reluctance to approach the expert because of the cost (severely damaging to some groups)
- Collaboration between groups was encouraged and was successful where it did occur

Lecturer Reflections

- Timing of the project (3 of 3) is crucial
- E mail costing procedure useful in an employability module.
  - Simulates sparse availability of domain expert
  - Student show perseverance rather than just giving up

Lecturer Reflections

- Questions to domain expert became well thought out and focused
- Lecturer takes on motivational / bridging role
- “Support” here means encouraging and allowing students to enhance their professional skills

Student feedback

Second and Third Years

Student Reflections

- “I think only having 5 e mails 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.”
- “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.”
- “I think our group should have asked more questions at the beginning (of project 3) 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.”

Student Reflections

- “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.”
- “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.”

Future Plans

- Cut down time for the project.
- Emphasise the importance of group planning and decision making.
- Cut down number of free contact e mails.
- Incorporate other methods of interaction.
- Formal evaluation of impact.

End on a happy note

- Plenty of this:
  - “The module has taught me so many things that no other maths module can teachs us so I would definilty recommend it to others” (2012 student).
  - “I have definitely increased in confidence” (2012 student).
  - “Covering a wide range of topics was very useful as there are so many sectors where mathematicians are utilised. Being able to get a taste of some of these matters helped me to see how we can apply a wide range of what we've learnt at university rather than following the general consensus of ‘when will I ever need to use this after the exam?’” (2013 student).

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