Preparing for the transition to professional work

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Introduction

This paper looks at the final outcome of a science degree program, and considers what happens when students leave university as graduates and the skills they have acquired (or should have acquired). In studying this area we are hampered by lack of data. To study the experience of the large numbers of students entering first year we have good data on students' entry levels (HSC results and so on), on students' demographic backgrounds and on their progress through university. This is available at our fingertips on most university computer systems. In contrast, data on graduates are much less extensive. Firstly, many departments do not keep information on their alumni, who are, in any case, spread far and wide. Graduates are no longer a captive audience and any data that are collected will be voluntary. One such source is the course experience questionnaire (CEQ), answered by students a few months after they finish their degree: about 70% of students complete the CEQ each year. In particular, there is no clear indication that students in science courses leave university with well-developed 'generic skills' such as concepts of ethics (professional or personal), sustainability, creativity, computing skills, information skills, communication skills, interpersonal skills and teamwork skills. This raises many questions: should we as science lecturers be teaching this material, should students be learning it as part of life, should graduates learn the skills on the job, should the careers services of the university be teaching these skills along with résumé writing?

This paper also looks at research on students' perceptions of their future work and career and the current research that is investigating the connections between these perceptions and their learning at university. We consider ways that professional work can be modelled in classroom activities so that students develop realistic ideas of the workforce and extend their range of proficiency in other areas.

The transition to university is well studied: it was considered at the UniServe Science forum in 2000. The students' experience in first year, as they make the transition to university, often includes large classes and huge potential for drop out. There are also uneven entry standards and all the issues of student affective response to the different environment. Many students only study science, or one particular discipline of science, at first year level, so the potential for problems in first year in terms of numbers of people affected, staff and students, is great. There is also the necessity to 'hook' students into science at first year or they will choose other degree programs. The forum web site at http://science.uniserve.edu.au/disc/fyerefs.html gives a summary of references on the transition and the first-year experience. A summary focusing specifically on mathematics in published in Wood (2001), while recent discussions involving statistics and the first year experience are given by Wild and Pfannkuch (1999) and Gal, Ginsburg and Schau (1997).

Ideas of generic skills were canvassed at another UniServe Science forum (2001). Again, this was very much in the context of beginning students and the first year experience. These skills included graphing and data analysis (basic quantitative literacy skills), generic skills in the context of scientific method and communication, with particular discussion of ethics, validating information sources, assessment and student perceptions. The section on communication skills (Zadnik, Radloff and de la Harpe 2001) described the benefits of students running their own professional conference and recommended the embedding of communication skills in the curriculum. They also recommended formal assessment of communication skills and explicit teaching of these skills.

Graduate skills and employability

What is our main aim in teaching students undergraduate science? Are we inducting them into a discipline or preparing them for the scientific workforce or the general workforce? Do we care about employability? Yorke and Knight (2003) summarise the views of the role of higher education and employability. Firstly, higher education can be a preparation for a profession, so employability can be defined as how well students are prepared for that profession; secondly, there is a view that university prepares students for any job by developing generic achievements so that employability is enhanced by the development of excellent generic achievements.

To find these generic achievements and get agreement on them is not easy. The large Australian study reported by Hambur, Rowe and Luc (2002) tested graduates over a range of graduate skills. They selected 5 cognitive dimensions to assess. Critical thinking, problem solving and interpersonal understandings were each tested using 30 multiple-choice items: argument writing and report writing were assessed using a writing task. The items were changed for context in different disciplines. These cognitive dimensions were selected after consultation with universities and other stakeholders such as employer groups and professional bodies. Employers preferred skills that helped their organisations with their goals, especially personal and interpersonal skills, which they listed as self management, effective oral communication, problem solving, logical and orderly thinking, creativity and flair in business, entrepreneurship, teamwork and leadership (p.24). The universities focused more on academic skills and qualities related to citizenship. The cognitive skills investigated in the study were chosen because they were measurable and appeared to be components of other skills. Major findings included those that may be expected, such as that Arts/Humanities students performed better on ‘critical thinking’ and ‘interpersonal understandings’, whereas Engineering and Architecture students did relatively better on ‘problem solving’.

The report is an important contribution to the discussion on graduate skills. Mathematics and Science students (grouped for the report) perform around average for all domains, slightly higher for problem solving and slightly lower for argument writing, and with less variability than students in other domains. Student specific variables such as motivation and ability appeared to account for much of the variance in the scores. Performance did not seem to be related to gender, age and English-speaking background. Another useful finding was that scores on the domains tested were significantly higher in later years of study. The authors express caution concerning this result, as the reasons for it are not clear. The numbers tested in the later years were smaller, and those who did not have the required skills may have dropped out, or there could be a variety of other explanations. However, if the finding is correct, and students are improving on these graduate skills, then this is a positive result for teaching and learning. Further research with larger and matched samples will assist with understanding these findings.

Other recent research focuses on successful graduates (Scott and Yates 2002; Scott 2003). For a particular field of study, several employers were selected and asked to nominate a group of their most successful recent graduates, about 20 in all. The graduates and supervisors were then interviewed in depth to ascertain the attributes that had contributed to the graduates’ success. From his research, Scott has developed a ‘framework of professional capability’ (Scott 2003; p.5). Scott’s research points out that it is when things go wrong, when an unexpected or troubling problem emerges, that professional capability is most tested, not when things are running smoothly or routinely. It is at times like these that the individual must use the combination of a well-developed emotional stance and an astute way of thinking to ‘read’ the situation and, from this, to figure out (‘match’) a suitable strategy for addressing it, a strategy which brings together and delivers the generic and job-specific skills and knowledge most appropriate to the situation. An example used by Scott is that if a professional is unable to remain calm and work with staff when things go wrong, then how much s/he knows or how intelligent s/he is may be irrelevant.

Another avenue of research is to consider those graduates who fail to find professional employment after graduation. In a small study of unemployed graduates, Knight (2003) found that lack of work experience, unrealistic aspirations, competition for jobs, poor degree results and poor career planning were given as reasons for their unemployment. They referred to the 'degree-work mismatch', feeling they had learned to execute a limited number of academic procedures well but remained deficient in areas such as self-presentation, self-motivation and communication. Many felt that they would need further qualifications before getting a job, and suggested that lecturers could include discussion about employability and careers as part of the curriculum from first year.

Several professional societies have grappled with the development of graduates, in particular in the area of ethics and professional responsibility. Engineers Australia and the Statistical Society of Australia both have codes of conduct for their members. Engineers Australia has a graduate program where they consider the professional formation of their graduates. Graduates have a mentor and development program that emphasises the competence and responsibility of an engineer. This approach could be beneficially used in other professional areas including science disciplines. Developing professional capability and finding professional employment is important for our graduates but so too is the influence of these ideas on learning at university. The following section considers research on how ideas of future profession influence learning.

Conceptions of future profession and approaches to learning

In one specific area of science, a study of students' conceptions of statistics was carried out by Petocz and Reid (Petocz and Reid 2001, 2003a; Reid and Petocz 2002) based on a phenomenographic approach (Marton and Booth 1997). They found that statistics major students have qualitatively different ways of understanding statistics and learning in statistics, ranging from limiting to expansive views. Students who describe the most atomistic and limiting views seem only to be able to focus their attention on fragmented and unrelated components in their learning environment. Conversely, students who describe the most integrated and expansive views are able to make use of a wide range of learning approaches to further their already sophisticated understanding.

Reid and Petocz (2002) introduce the abstract notion of the 'Professional Entity' – a way of thinking about students' (and teachers') understanding of professional work (based initially on studies in music, see Reid 1997). It consists of three different levels: the *extrinsic technical* level describes a perception that professional work is constituted as a group of technical components that can be used when the work situation demands it; the *extrinsic meaning* level describes a perception that professional work is about developing the meaning inherent in discipline objects (eg, data, in the area of statistics); and the *intrinsic meaning* level describes the perception that professional work is intrinsically related to a person's own personal and professional being. The significance of the Professional Entity is that there are specific conceptions of teaching and learning associated with each of its levels: a way of viewing the world of professional statistics corresponds to a particular approach to teaching and learning.

Further research in a wide variety of professional areas, including design (Davies and Reid 2001), accounting (Jebeile and Reid 2002), law (Reid 2003) and mathematics (Reid, Petocz, Smith, Wood and Dortins 2003) indicates that the Professional Entity is a concept that seems to be applicable to students' studies of many different professional fields, and it seems that it would be applicable to the wide variety of professional careers in science. Further research is presently investigating how the framework may need modification for students studying in areas that are only one component of their future profession, for example, servicing statistics for life sciences students, mathematics for future engineers, or sustainability for students of environmental science. Initial results indicate that the concept will be useful in such situations (Petocz and Reid 2003b).

Implications for teaching and learning in science

All the research leads to the conclusion that 'while technical expertise is a necessary capability … it is certainly not sufficient' to produce a successful graduate (Scott and Yates 2002). We need to consider the whole learning experience of undergraduates, not just what is taught and assessed. An integrated approach to course design across an undergraduate program seems sensible, but one of the main barriers to the introduction of explicit teaching of graduate skills is historical. The curriculum has developed and evolved over time and focuses on content-based subjects within one or two disciplines. The content of subjects is revised frequently, but usually not the assessment or broader skills. At many institutions, there is choice in a science degree so students have some freedom to choose their majors and electives; hence, ensuring a structured series of subjects is problematic.

Student resistance to the introduction of non-technical skills is well known. Students are vitally interested in their careers, but often feel that the technical skills are the ones that will give them employment, not the collateral skills acquired through their degree. In his study of unemployed graduates, Knight (2003) found that 'resistance to wise messages helps to explain the unemployed situation in which these graduates find themselves'. This study also highlighted an interesting dilemma: two of the ex-students were unemployed due to ethical issues. Their ideals were restricting their choice of employers. For areas such as mathematics, where many of the jobs are in defence or finance, will ethical considerations narrow students' employment choices? On an administrative note, many departments do not keep contact with their alumni and this makes it difficult to see where their students have gone and whether they are having difficulty with gaining appropriate employment.

Britton (2002) considers the transfer of knowledge. She examined how the skills and concepts learnt in mathematics classes were transferred to applications in other disciplines (microbiology, physics and computer science). There were significant problems with terminology, notation and imprecise use of mathematics by the other disciplines. Results showed that students who performed best on the decontextualised mathematics questions appeared to be able to transfer skills better to questions in context. Her paper emphasises the need for communication with other disciplines and the important influence of small features, such as notation, that can really confuse learners.

Many of the changes suggested by the research may be unpopular with students and staff. Students will need to learn more than technical skills and lecturers will need to expand their repertoire of teaching and learning situations. One of the ways that this can be achieved within the classroom is through the modelling of professional work. It is important for the lecturer to explain the reasons for the learning situations and make the connections between work and the learning explicit.

Modelling professional work

There are many traditional approaches to introducing professional work into undergraduate studies. These include fieldwork, excursions, laboratory work and computer simulations. Using modelling such as in-class conferences to develop communication skills is described in Wood and Perrett (1997) and Zadnik et al. (2001). The development of communication skills and quantitative analysis skills for reading research that uses statistics is published in Wood and Petocz (2003) and described in Wood and Petocz (2002). These materials use real sources with carefully designed questions that encourage students into broader conceptions of their subject and link their study to professional work. Questions cover areas of critical reading, ethics and critically examining the use of quantitative analysis. Coutis and Wood (2002) evaluated this model in the context of teaching statistics to optometry students. The lecturers were able to point to the requirements of the professional society that wanted quantitative literacy skills in their graduates. Students could clearly see that graduates in the field needed the work they were being assessed on at university.

In areas where it is too time consuming, expensive or dangerous to take students into the field, one option is to bring the outside world into the classroom. This is particularly effective for motivation and for demonstrating professional roles, such as that of an engineer (Wood, Petocz and Smith 2000) or a statistician (Petocz, Griffiths and Wright 1996). Such videos model the role of the professional using visual means to motivate the learning of professional skills, and the variety introduced by the use of a different medium has proved popular with students (Petocz and Wood 2001). Other ways to bring the professional world into the classroom are case studies or guest lecturers/experts.

Assessment is a major area where professional work can be modelled. Students can work in teams, with real data (often from the Internet), preparing explanations for different audiences and discussion of results (see, for example, Reid and Petocz 2003). Explicit teaching of teamwork skills, communication skills, negotiation skills and project management will contribute to graduate attributes listed by employers. Additionally, we can create opportunities for broader discussions in class about aspects such as learning approaches, conceptions of the subject and the profession. Other professional skills and concerns, such as sustainability and ethics, can be discussed and can even form part of assessed work.

The teaching suggestions here are not exhaustive and one method is not better than another. Integrated learning and transfer of skills will need a variety of approaches. When planning curriculum, lecturers should consider the development of skills over the course of a degree and plan learning situations accordingly. For example, in a major made up of several subjects you may want to cover all the communication skills. For that reason, one subject may require the students to present seminars, another may have students working in teams on a project, another may involve collecting data from a field trip and writing up a report. Above all, there is a need for recognition of the importance of the concept of professional work and a willingness to engage with such issues.

Conclusion

The transition to the workforce is important. Firstly, perceptions of the workforce and working as a professional undoubtedly influence students' learning whilst at university. Secondly, the graduate skills and attitudes developed have the possibility of being transferable across discipline boundaries. While there may be disagreement about exactly which skills and affects are required for the workforce, we can still expand the variety of tasks and learning situations that we design for students.

Modelling of professional work situations, such as fieldwork, working in teams, writing reports and so on, is useful for the development of students' perceptions of work. To quote two students who had watched one of our statistics videos (Petocz et al. 1996), 'For the first time in my life I saw and understood what the jobs that I might do when I graduate actually look like', and 'That's the first time it's convinced me that we actually use that [probability] in real life'. An essential task for the lecturer is to make such learning situations explicit so that students can make the connections between the learning situation and their future professional careers. The evidence that this perception of future work influences a student's learning is mounting. The evidence that lack of knowledge of future work possibilities influences subject and degree choice is also clear.

Current research is looking at development of graduate skills and attributes, features of successful graduates and of unemployed graduates, how teaching and learning influence the development of graduate attributes, and conversely how the concept of work influences learning. There are many questions raised. The collection of data from graduates is difficult (and expensive). It seems important that in order to assist with the development of teaching and learning, departments and universities should improve connections with their alumni to track the destinations of all graduates.

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