

## APPLYING A MODEL OF PROFESSIONAL LEARNING TO CASE STUDIES IN STATISTICS EDUCATION

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*University students are generally aware that they are preparing for professional working life, and they use this as one focus for their learning. We have carried out interviews with over 500 students, in separate projects in Australia and Sweden, in a variety of discipline areas (including statistics). Based on these, we have developed a model of professional learning that incorporates students' views of learning for their profession, the nature of knowledge in their discipline, and their development of professional identity. We describe this model and illustrate it by presenting case studies of two students undertaking a degree in mathematical sciences, majoring in statistics. The model gives us a framework for investigating pedagogical approaches. It allows us to examine how knowledge is presented in our courses, to analyse students' class and assessment responses and to better support students' professional formation.*

### INTRODUCTION

In the early 21<sup>st</sup> century, students enter university with the idea that their studies should be useful to them. Most students undertake programs that have strong orientations towards a specific field, and students seem to be aware that there is a value associated with their studies that enables them to enter professional working life (Abrandt Dahlgren et al., 2008). The way in which students approach their studies may be related to the way they appreciate their progression as novice professionals through their development of professional identities (Reid et al., 2008). In our previous research, two separate projects carried out in Australia and Sweden, we have developed a model of professional learning based on interviews with a large number of students in a variety of disciplines. In this paper, we describe this model and illustrate it by applying it to two specific case studies of students majoring in statistics. We believe that there is a benefit for statistics education in utilising such research results from discipline areas beyond statistics.

This idea of 'cross fertilisation' seems to be under-utilised in research and writing on statistics education, which mostly stay within the boundaries of statistics or related and overlapping disciplines such as mathematics, psychology and science (see Garfield & Ben-Zvi, 2007, for example, and note their call to collaborate with different disciplines). There is some evidence (Scott, 2006, p. 34) that different disciplines focus on a limited range of learning (e.g., team projects in management, practicums in education, clinical placements in health), and this may also limit the approaches to pedagogical research in each discipline. Yet results from quite different disciplines can be usefully applied to statistics education, for example, Shreeve et al.'s (2004) research into students' ideas about assessment (discussed in Petocz & Reid, 2010). In this paper, we make explicit use of results that were obtained from studies in a diverse range of disciplines, including music, politics, law and design, as well as mathematics and statistics.

The notion of re-use or re-analysis of qualitative data has received some attention in the literature (Kinzie et al., 2007). We have described our approach of combining, re-analysing and extending qualitative data from different projects by the original researchers and have referred to this as 'qualitative meta-analysis' (Abrandt Dahlgren et al., 2008). Since the original researchers are involved in the re-analysis, we are able to use the original data as well as the summarized results. As opposed to a quantitative meta-analysis, which aims to increase the empirical support for a particular position, a qualitative meta-analysis aims to enrich previous analyses.

The research projects that were used for the qualitative meta-analysis are the Professional Entity project carried out in Australia, and the Journeymen project carried out by a European Union team. Each was originally analysed using a phenomenographic approach (Marton & Booth, 1997). The general relations between education and work were summarised by the Australians as the Professional Entity (Reid & Petocz, 2004), a three-level hierarchy of views of professional work

and corresponding relationships to study. The most limiting is the *extrinsic technical* level, in which students describe a perception that professional work consists of a group of technical components that can be used when the work situation demands it: the corresponding approach to study is focused on acquiring and practising these technical components. At the broader *extrinsic meaning* level, students hold that professional work is about developing the meaning inherent in discipline objects, and focus in their studies on investigating the discipline objects to explicate the meaning in them. The broadest conception is the *intrinsic meaning* level, in which students perceive that their professional work is related to their own personal and professional being, and include a strong personal connection to their learning.

The Swedish group in the EU Journeymen team summarised their findings in terms of students' differing trajectories of knowledge use and identity formation between education and work life (Abrandt Dahlgren et al., 2006). In particular, they developed the constructs of *ritual* and *rational*. It seems reasonable to assume that all educational programmes include *rational* knowledge and skills that prepare students for a specific discipline or profession, emphasising the utility value of knowledge. Some of these are comprised of *substantive* skills that are content specific and contextually situated, while others are *generic* skills, transferable between different contexts. Besides the *rational*, some programmes also include an aspect that is *ritual* in character, where the connection to a specific context of application is lacking and the most important feature is the exchange value of knowledge.

Together, the two projects enabled us to develop a model of professional learning that can be utilised to develop curriculum or applied to investigate the experience of individual students. We will describe the model in the next section, and then use it to investigate the transcripts of interviews with two students majoring in statistics. The aim is to understand and interpret these statistics students' experiences of learning and professional formation, and to give some indication of how similar analysis could be undertaken with other students.

#### A MODEL OF PROFESSIONAL LEARNING

Our model of professional learning at the interface between higher education and professional working life is based on the critical components identified in the qualitative meta-analysis of our two research projects, and is presented in figure 1. This model combines the broader categories from each project—the *extrinsic technical*, *extrinsic meaning* and *intrinsic meaning* aspects of the Professional Entity and the *ritual*, *rational substantive* and *rational generic* aspects of the Journeymen results. The horizontal dimension refers to views of learning for professional work, while the vertical dimension refers to views of knowledge for the profession. The diagonal direction refers to concepts of identity as an experienced student and novice professional, and to engagement with studies and profession. These derived or second-order categories are construed by bringing about a new encounter between the original categories and the empirical materials. The model combines the two aspects of learning for professional work and knowledge in the specific discipline and profession, interacting in the notions of identity and engagement.

The arrows in the diagram represent the inclusive nature of the categories in the horizontal and vertical dimensions. The broadest *intrinsic meaning* aspect includes the *extrinsic meaning* and also the most limiting *extrinsic technical* aspects, and the broadest *rational generic* aspect includes the *rational substantive* and also the most limiting *ritual* aspects. This inclusivity is both logical and empirical, as is often observed in phenomenographic studies. For instance, *rational generic* knowledge includes specific instances of application in the discipline, and hence *rational substantive* knowledge, which in its turn includes *ritual* knowledge as rational knowledge whose function has not (yet) been explained. The derived categories in the diagonal direction inherit inclusivity from the horizontal and vertical categories.

The model can be applied to individual students or to discipline groups of students, both in terms of a snapshot at a particular time and in terms of development. As educators, our preferred direction for development is to the right and downwards, and our preferred position for our students is in the bottom right of the diagram. This is both a value judgement and a consequence of the inclusive nature of both hierarchical dimensions. Holding broader conceptions of learning for work or knowledge for the profession gives students access to the whole range of conceptions to use as they need, whereas holding the narrowest conceptions limits them to those views alone.

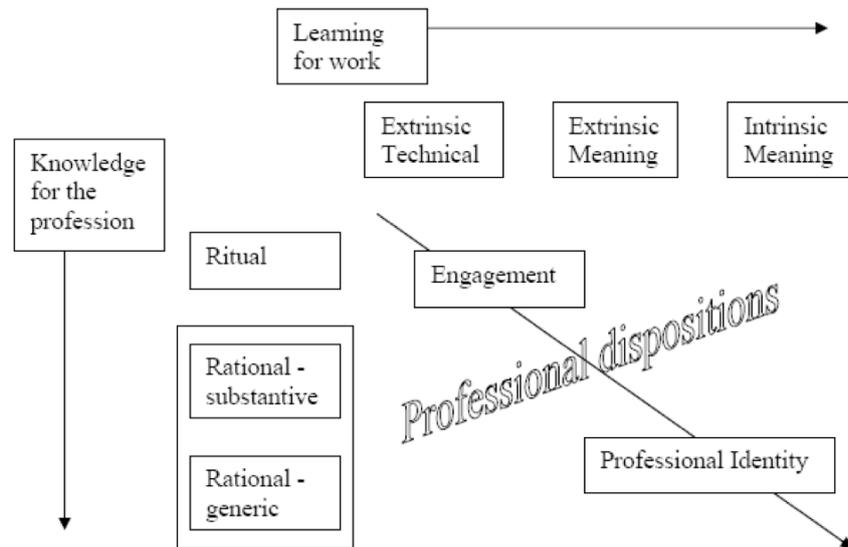


Figure 1. A model of professional learning, from Reid et al. (2010)

Based on empirical results from the original studies, we know that where students position themselves early in their studies depends on a number of factors: the status and perception of the particular profession, the view of knowledge and associated pedagogic tradition in the profession, students' individual conceptions of learning and perceptions of the discipline they have chosen for study, and their knowledge of the particular profession and its approach to work. These factors may be different in different countries, and are certainly different for different students.

The pedagogic approach taken in their university courses will influence students to change their position on these two dimensions, though students with differing backgrounds and experience are likely to react in different ways to the same pedagogy. For instance, 'fixed factual' knowledge selected by a lecturer and presented without argument is likely to be experienced as *ritual* and incline students towards an *extrinsic technical* view of the profession (for example, presentation of statistical techniques in a traditional 'engineering statistics' course). On the other hand, an educational program that links studies to work with authentic tasks may incline students to appreciate the *rational generic* aspects of discipline knowledge and to make the personal connection to their profession that is characteristic of the *intrinsic meaning* view (for example, a problem-based learning course in statistics for psychology).

#### CASE STUDY 1: HUNG

We interviewed Hung towards the end of his last (third) year of a degree in mathematical sciences, majoring in statistics, and we give a summary of some aspects of this interview (note that our interview questions are shown in square brackets and Hung's responses in italics). Hung chose his major on the basis of previous experience: *I enjoyed mathematics at High School*. However, he had little experience or knowledge of statistics as a future profession: [Can you give details of how you think you can use statistics in the work place?] *I haven't really joined the work place; it's really limited. I am not really sure.*

Hung talked about statistics in terms of technical components and disparate topics, usually summarised by the titles of the courses that he had taken: *In Statistics 2, that is really theoretical and in Statistics 1 we just had lab work and a couple of assignments. Regression I think is really practical.* His approach to learning is correspondingly atomistic: [How do you know you have learnt something in statistics?] *If I can keep doing different questions relating to the same problems over and over again without having to look back or getting any mistakes in them.* This seems to indicate an *extrinsic technical* approach to learning for his future profession. Occasionally, he broadens this to the *extrinsic technical* aspects: [Can you tell me what you find interesting or important about statistics?] *Just the different problems you get or the real-life application of regression analysis. I find that the most interesting.* [Why?] *It is interesting to fit models to data.*

He seems to see the knowledge he is acquiring in his studies as *ritual*, and describes some statistical knowledge as more practical – *rational substantive* – but only *practical in terms of some subjects that sound ridiculous that have ridiculous topics and I don't think it is related to anything that we do. /.../ Statistics is the most practical of all the subjects, topics that we cover, /.../ but something like Analysis, I just doubt whether you are going to use that in the real world or anything. Just covering the basics of mathematics, just making it more difficult for everyone.*

His engagement with his studies and his future profession seems to be correspondingly narrow, very much from the point of view of a student carrying out the tasks required and aiming at passing the final examination: *Then you can actually relate all your study towards that, understand work related to the final exam.* He shows some frustration with the course's focus on theory: *Because sometimes it just gets really boring and you just have basic rote learning type questions and you really want to expand and do more practical questions. It just stops at the theoretical questions, and that's pretty boring.* And he is also unhappy with the pedagogical approaches that some of his lecturers have used: *They just keep writing unnecessarily and at the end of the lecture you have just written 20 pages or whatever and you've just got nothing out of it.*

Hung's view is very much pre-professional, with limited knowledge of professional work. He describes his aim in learning as: *Probably furthering my career. I mean it has hopefully some aspects of finance, statistics to go further on with my career.* Although he is towards the end of his university studies, his professional identity is still unformed, though he is willing to speculate about his forthcoming transition to professional life: [How do you think learning about statistics will help you in your career?] *I think in understanding more things in real life problems I suppose if you understand the statistics and how it works, that is what is most helpful in your career. /.../ I mean if you just have words that mean nothing to you, it's pointless; if you could understand statistical terms behind what you are doing, it's pretty good.*

Overall, examination of Hung's interview shows a student located in the top-left corner of the model of professional learning in figure 1. He views learning statistics in an *extrinsic technical* way, occasionally broadening to *extrinsic meaning*, and he understands knowledge in the discipline as mostly *ritual* and occasionally *rational substantive*. His level of engagement seems to be correspondingly narrow, driven by the extrinsic requirements of his assessment and a vague notion of 'furthering his career'. His professional identity is not strong, though he is aware that he will need to develop this in the near future.

Hung's transcript indicates to us various areas where the pedagogy of his course needs attention. Most obvious is the inclusion of explicit reference to future professional practices and requirements, both substantive and generic, and it seems that he would be receptive to such a change. The pedagogical approach of focusing on theory using a transmission mode of teaching could also be strengthened to include more practical application in professional problem contexts.

## CASE STUDY 2: CHRIS

Chris is in the third year of her (3 or 4 year) degree in mathematics and finance, which contains a large amount of statistics (equivalent to a statistics major though with a focus on financial contexts). Like Hung, Chris has had no work experience or experience of part-time work in her future profession, though she seems better informed about her options (see the later quotes).

Chris talked about statistics in terms of setting up models of financial and other situations, and using them to solve real problems: *I find statistics the most applicable because the thing is you are dealing with real life situations. /.../ It also helps me understand more in some of the financial models that are being used nowadays, /.../ so it ties in with business and finance related subjects, so that's good for me.* She described her learning of statistics in similar terms: *Well, I think in learning statistics you can achieve a lot in terms of trying to find solutions to all problems. /.../ You're trying to come to conclusions, basically, so you've got all these different choices and narrowing it down to try and come to a conclusion, do you know what I'm trying to say? So basically you can use it, it helps you to try and find solutions to problems, basically, and that is useful and important, because it helps in all of research and work, and things like that.* The focus on models seems to indicate an *extrinsic technical* approach to learning for work, and there also seems to be a broadness and personal connection characteristic of the *intrinsic meaning* aspect.

Her view of professional knowledge includes the *rational substantive* aspect of creating and utilising statistical models, and also the *rational generic* aspect of developing a mode of thinking and an approach to solving problems: *It helps my thinking in terms of structuring models, because statistics, regression analysis, is one subject I've done that helps us create models and look at modifying models, like, statistical models, but I haven't really done something like this in my other subjects, so it also helps me. It trains my thinking to be able to come up with a good solution when looking at a whole model and looking at all those different variables, do you know what I'm saying? So that's one thing it's helped me in, so it's helped my thinking a lot as well.*

Chris's level of engagement is correspondingly broad, and starts with the basics: *Well, I enjoy statistics in general. I think it's very interesting. What I get personally out of it, well I basically just enjoy the subject.* She frequently mentions her broad reading and study, and certainly doesn't limit herself to the course requirements: *When I do my own reading, it [statistics] actually helps me understand the context of that business subject, so it ties in with business and finance related subjects, so that's good for me.*

Her engagement with her studies is clearly helped by establishing a connection with her future profession: *Our lecturer really made it as if, treated us as if we were working, like, giving us real life problems. Because our lecturer is a consultant, and he also gives us problems that he gets from clients, to us as assignments, so that helps, that's very critical, I think, in regression analysis, because I've learned just how useful it actually can be, and how the results it comes up with are fairly important in terms of trying to find the effects of variables or situations.*

Although she has not yet had experience of professional work, she has seriously considered this coming transition and the role that her current studies might play in the workforce: *I want to go to investment banking. Yeah, you can use stats in there, I'm pretty sure. I believe stats is applicable in all areas, because in every single thing we do, whatever project we're working on when we come to work, there are a lot of variables that affect that project. And if you want to find out what different variables have an effect, stats can be used, OK.* This links back to her approach to learning, aided by appropriate pedagogy: *The lecturer helps us see the more practical side of things – that could be one reason why we see more practical – and helps us deal with real situations and look at real data and see how it really affects the whole model.*

In summary, Chris's interview shows a student located towards the bottom-right corner of the model of professional learning in figure 1. She sees her discipline of statistics in an *extrinsic meaning* way, broadening sometimes to include *intrinsic meaning* aspects. Her view of knowledge in statistics includes *rational substantive* and *rational generic* aspects. Her level of engagement seems broad and firmly based on a strongly-developing professional identity, aided by her awareness of aspects of the pedagogical approach of much of her course.

## CONCLUSION

Previous research about the relationship between higher education and working life has often focused on the match between the output of higher education and the societal demands for academically trained workers, or studies on the expediency of higher education as assessed retroactively by professional novices. What we have shown by these examples is a different perspective on the relationship between higher education and working life – students' views of what it is actually like to 'become' professional. The students' accounts show that the pedagogy of their educational programs (in this case, their statistics programs) seems to produce different processes of professional identification, which is important knowledge for professional educators. From the two examples provided in this paper, we can see that students in the same pedagogical environment can perceive different things about the importance of their learning for work. There is an interplay between the forms of knowledge as experienced at university, their expectations regarding future professional work, and the manner in which they then approach their studies.

Work in qualified positions in contemporary working life requires a perspective on competence that, in addition to specific knowledge and skills, also includes abilities of independent learning. From our research across a large number of educational areas and students, we have evidence to suggest that if the content of the teaching helps to develop the substantive knowledge, it is the pedagogy and teaching forms that seem to foster professional identification processes and develop generic competences. Pedagogies that require students to engage actively and reflectively

with their peers, and provide access to professional role models, seem to start the process of professional identification earlier than in traditional, teacher-led programs. Graduates from programs characterized by such pedagogies also seem to make the transition from university to working life more smoothly. In a time when there seems to be major reshaping of educational institutions and workplaces, and when there is a lack of stable forecasts about the nature of future tasks in working-life and qualifications needed, research about the impact of learning communities in higher education and how graduates construe themselves as professionals can provide important information for the educational design of higher education. In this sense, it may be appropriate for statistics educators to evaluate and rethink the knowledge claims and pedagogical approaches across the curriculum in order to seek ways of supporting students' transitions into their life-time occupations.

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