Differing Ways that Computing Academics Understand Teaching

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Abstract

This paper presents first results from a wide-ranging phenomenographic study of computing academics' understanding of teaching. These first results focus upon four areas: the role of lab practical sessions, the experience of teaching success, conceptions of motivating and engaging students, and the granularity of the teacher's focus. The findings are comparable with prior work on the understandings of academics in other disciplines. This study was started as part of a workshop on phenomenography. Most participants at the workshop received their first training in phenomenography. This paper summarises the structure of the workshop.

Keywords: phenomenography, conceptions of teaching, computing education.

1 Phenomenography

While most readers of this paper would be familiar with the dual concepts of deep and surface learning, fewer might know that the origins of these concepts lie in phenomenographic research. Phenomenography is a research approach that focuses on the qualitatively different ways that people experience, understand, perceive, or conceptualise a phenomenon (Marton 1986; Marton & Booth 1997; Berglund 2005).

A phenomenographic researcher typically gathers data by interviewing a number of subjects about a particular phenomenon. Analysis of the interviews then seeks to identify *variations* in the interviewees' perceptions of the phenomenon. Even when many people are interviewed, the analysis generally elicits only a small number of qualitatively different ways of experiencing the phenomenon.

These ways of experiencing the phenomenon are then delineated as distinct 'categories of description'. Each category represents a different conception, a different understanding, of the phenomenon being studied. It is often the case that the categories are hierarchical, with each new category supplementing, rather than supplanting, the lower levels of understanding.

Importantly, what is being categorised is the understandings, not the people who evince them. It is common for a single person in a single interview to express understandings from several different categories in the same hierarchy. The aim of a phenomenographical study is not to pigeonhole people but to categorise the full range of understandings of a phenomenon.

1.1 Phenomenographical studies of computing students

The seminal phenomenographic work in computing education was a study of student's conceptions of learning to program. Booth (1992) identified four qualitatively distinct ways in which students experience learning to programming: they experience it as learning a programming language; as learning to write programs in a language; as learning to solve problems; and/or as becoming part of the programming community.

Other phenomenographic work on student conceptions of programming includes that by Bruce et al (2004) and that by Stoodley et al (2004). Some very recent phenomenographic work explores student understandings of object-oriented concepts (Eckerdal & Thuné 2005; Eckerdal & Berglund 2005).

Further phenomenographic studies of computing students have explored educationally critical aspects of learning about information systems (Cope 2000) and students' understandings of network protocols (Berglund 2005).

1.2 Phenomenographical studies of academics

Academics' understandings of their teaching have been the subject of several past phenomenographic studies, most often of science teachers (Samuelowicz & Bain 1992; Prosser et al 1994; Trigwell et al 1994), but also in other areas such as mathematics (Runesson 2005), accounting (Levesson 2004), and economics (Pang & Marton 2003).

There have also been cross-disciplinary studies. The four personal theories of teaching by Fox (1983) are based upon his anecdotal encounters with newly appointed polytechnic teachers for "a number of years" (p151), probably across a variety of disciplines. The 55 academics studied by Dunkin (1990) were spread across many disciplines. Samuelowicz and Bain (1992) interviewed 13 teachers, five who taught "science" (presumably one or more of the physical sciences) and eight who taught in the social sciences.

All of these studies have identified several qualitatively different understandings of teaching that teachers bring to the classroom. At one extreme, teachers focus on the content of their course, seeing teaching as the act of transmitting knowledge and concepts to the student. At the other extreme, teachers focus on the student, seeing teaching as the act of helping students to develop or change their own understandings.

Why are there so many phenomenographic studies of academics, ranging across so many disciplines? As Prosser et al (1994) explain, a person's understanding of teaching or learning

> "*… needs to be identified and described within particular contexts, in terms of particular tasks and from the perspective of the learner or teacher within that context engaged in a particular task*" (p219)

Some characteristics of computer science as an academic discipline make it hard to learn and to teach: the subject area changes fast; it is known to be hard to learn (Ben-Ari 2001); it is simultaneously abstract or theory-based and concrete or skill-based; it requires an understanding of both the static and the dynamic properties of a computer. Therefore it would be no surprise if the ways computing teachers understand teaching were to differ from the ways teachers in various other disciplines understand it. Given Prosser's thoughts on the importance of context, it would be unwise to assume that the results from any of these studies transfer directly to computing.

While all of the studies referred to above identified different conceptions of teaching, and indeed different numbers of categories, all of their categories fell into two broad and well known groups, content- or teacher-focused and student-focused.

An early study that in some ways set the scene for this grouping is that by Fox (1983). Fox established four categories, or personal theories of teaching, two in each group.

1.2.1 Content- or teacher-focused conceptions

Within the broad content- or teacher-focused category, Fox identifies two further categories of understanding, 'transfer' and 'shaping'.

In the transfer understanding of teaching, the focus is upon the knowledge of the discipline, with the student being a container into which the knowledge is to be poured.

In the shaping understanding of teaching, the student is viewed as a raw material to be moulded, or turned by some other 'manufacturing' process into a finished product. The domain knowledge is still the primary focus, and that knowledge is a specification of the product.

1.2.2 Student-focused conceptions

Within the broad student-focused category, Fox again identifies two categories of understanding, 'travelling' and 'growing'.

In the travelling understanding, education is seen as a journey. Students have a 'guide' (a teacher) who leads them through the countryside, pointing out the major landmarks. While the discipline knowledge (the countryside) is still seen as separate from the student, the focus in this conception is on the student who is making the journey.

In the growing understanding, a pure constructivist perspective, the domain knowledge has no existence independent of the human mind. To explain this concept, Fox quotes Northedge (1976):

> *"In this case we conceive of the teacher as a gardener with the student's mind, as before, an area of ground. But this time I suggest we view the ground as already covered with vegetation (concept systems), some of which is clearly worth retaining and cultivating."*

2 A phenomenography workshop for computing academics

Phenomenography is less widely used and less well known in computer education research than in education research in general. Even when recognised, the method is likely to be seen as not particularly useful or relevant. In a thorough survey of methods used to evaluate computer science teaching, Carbone and Kaasbøll (1998) wrote that

> *"[Phenomenographic] studies like Booth's are powerful ways for understanding how students think and how our teaching succeeds or misses out. Training as a social scientist is necessary to carry out such studies, and the studies are time consuming, so they are beyond the capabilities of most computer science teachers."*

To help address this situation, the first five authors of this paper devised a two-day workshop that would introduce more computer education researchers to phenomenography by involving them in a major project.

It was clear that an empirical study focusing on computing academics' perceptions of teaching would not be redundant. While one or two such studies have appeared recently (Lister et al 2004, Kutay & Lister 2006), much of the ground remains uncovered. A project such as this would provide a vehicle for teaching the use of phenomenography, while at the same time investigating whether the results of the earlier multidisciplinary and single-disciplinary studies have any bearing on understandings of teaching within the discipline of computing.

This paper briefly describes the workshop and presents some preliminary results from the phenomenographic research project around which it was built.

2.1 Prior work

Prior to the workshop, participants were required to read several papers (Åkerlind 2005; Booth & Ingerman 2002; Eckerdal & Thuné 2005; McKenzie 2002) and selected parts of a book (Ramsden 2003).

Also prior to the workshop, participants were required to interview one or more colleagues about their teaching and to transcribe the interviews. The interview script and instructions given in the appendix of Kutay and Lister (2006) were adapted to the purposes of this workshop.

In addition to the interview transcripts produced by the workshop participants, the transcripts from the Kutay and Lister study were also used as data for the workshop project, giving a total of 25 interview transcripts.

2.2 The workshop meeting and group work

The workshop itself occupied the two days immediately prior to ACE2006 in Hobart, Australia. It began with about half a day of formal instruction on phenomenography. Participants began working with the collected transcripts in the afternoon of the first day. By the end of that day, participants had broken into four groups and each group had chosen a topic area for their analysis of the transcripts:

- Group 1: The role of lab practicals
- Group 2: Conceptions of success
- Group 3: Motivation
- Group 4: Granularity of focus

The groups' findings within their respective topic areas are described in the next four sections of this paper.

The second day began with another hour or so of lecture, after which the participants returned to their groups to continue their analysis of the transcripts. The groups then came together to present their preliminary findings, and the workshop leaders made suggestions as to how to proceed from that point.

2.3 Post-workshop analysis

The groups continued analysing the transcripts for several weeks after the workshop. These collaborations were sustained by email, voice-over-IP, and other means of communication. Periodically, when each group felt ready, they presented a written report of their findings to the workshop leaders, who responded with feedback. Most groups benefited from at least two iterations of feedback.

Sections 3 to 6 of this paper are reports on the findings of each of those groups. We have not attempted to synthesise the work of the groups into a single coherent whole; rather, we present them as four separate but related studies of the same interview transcripts. As a unifying feature, however, we compare the findings of each group with Fox's categories of transfer, shaping, travelling, and growing.

The interview transcripts as used at the workshop were anonymous. The names of people and institutions were removed, along with such things as explicit degree or subject names that might have identified the participants. Each transcript was given a code, and in the sections that follow, quotations from the transcripts are marked with these codes.

3 Group 1: The role of lab practicals

One group at the workshop investigated the understandings of lab practicals, which they defined as classes in a computer lab in which students work to learn the use of a software tool, device, or similar. For example, if students were seated at computers using word-processing software, their class would be called a lab practical if they were learning word-processing, but not if they were using the word processor to write about, say, database design and implementation. In the transcripts these classes are called by a variety of names, such as labs, workshops, or tutorials.

This group identified four categories of understanding of the role of lab practical classes:

- Acquiring and practising skills
- Reinforcing lectures and textbooks
- Refining and troubleshooting
- Applying skills

These findings are presented in detail in Simon et al (2006), and are summarised in the following four subsections.

3.1 Acquiring and practising skills

When understanding the practical class as a means of acquiring and practising skills, academics perceive the class as somewhat independent of lectures. While the lectures will deal with the theory component of the course, the practicals are where the students learn about, acquire, and practise specific IT skills.

> *"There's nothing particular in the labs that reflects back on general lecture material. Because the labs are primarily focused on the Haskell language, it's obviously related to any Haskell lectures I give, which is early in the semester, so there's a kind of one-to-one correspondence there. But there's not a great deal of correspondence to the general material or conceptual material that's spread widely in [the course] because the labs are really focused on mainly learning a brand new programming paradigm, which is only one part of the whole course. So there's not a great deal of cross-linking." (L1)*

At this level, the class is highly structured and the teacher tends to assume the primary responsibility for the learning experience.

3.2 Reinforcing lectures and textbooks

When understanding the practical class as a means of reinforcing lectures and tutorials, academics see it as the opportunity for students to put into practice the skills that they have been taught in the lecture or the textbook. The learning is teacher initiated with focus on content. What is learnt at the practical is determined primarily by the teacher. The lectures, for example, will be used to teach and demonstrate a particular skill; then in the practical class, students will be given exercises in the application of that skill.

> *"They link with the lectures in that we'll cover something in the lecture, or I'll say 'you can do this', and in the labs we'll see how to actually do it." (E4)*

While the class is still fairly structured, the students assume some responsibility for the learning experience, and would not be expected to benefit greatly from it unless they have studied the lecture or textbook material.

3.3 Refining and troubleshooting

When understanding the practical class as a means of refining and troubleshooting, academics expect the students to do the bulk of the skill acquisition in their own time, and perceive the practical as a facility whereby students are provided with help on aspects of the work that they have found problematic.

In this category the student is expected to spend significant time prior to the lab acquiring the skills in question, so that the practical can be a productive troubleshooting session.

> *"Well, I really like it if they do some themselves. Two things I expect beforehand. First of all... I encourage them... to work through the whole of the textbook so that when they come to the tutorials, they're just doing the exercises that I've set them. And, if possible, they can do the exercises before the tutorial; then they only need to come to the tutorial and ask about anything they had trouble with, and they can perhaps go home early." (E4)*

Responsibility for learning is now predominantly the student's.

> *"Some students will have done all the questions, and come in ready with their questions, the ones they had trouble with. Other students won't have done anything, and they'll start working... Everyone's working at their own speed, covering the material. Some students will do all the questions, some won't. It depends how much they're willing to do beforehand at home." (E4)*

3.4 Applying skills

When understanding the practical class as a means of applying skills, academics no longer expect skills to be acquired in the class. The troubleshooting assistance is still provided, but in the context of applying the skills to a particular task such as a project or a major assignment.

As with the previous category, the students are expected to acquire the skills in their own time (or perhaps in earlier practical sessions), so that this practical can be devoted to work on the project. The practical is now of less importance than the prior work, and can indeed become optional.

"An hour a week of tutorial / computer laboratory. Not many turn up to that very often; although they're available, they normally do it in their own time." (E1)

Responsibility for learning is thus almost entirely the student's, with the academic providing few or no instructions.

"The following four [classes] are, as I say, basically one-liners, saying implement the philosophies and material from the [lectures]; for example, it might have been on help, it might have been on how to implement pop-up help in a web [page], so the tutorial might just say 'implement pop-up help in your assignment'. And that's it; that's what the tutorial says... I'm trying to wean them off, as much as possible, specific instructions on how to do a particular job, and get them to think about how it should be done." (E3)

3.5 Relationship to prior work

This group identified four categories of description of the lab practical class, which bear a passing correspondence to the four categories of Fox.

Experienced as a means of acquiring and practising skills, the practical appears to conform to Fox's transfer category. As a way of reinforcing skills taught in lectures or the textbook, it could perhaps be seen as shaping. As a class for refining and troubleshooting, it is not unlike travelling. And as a means of applying skills acquired elsewhere, it fits clearly into the growing category.

4 Group 2: Conceptions of success

A second group focused on how IT academics experience success in their teaching. Of the 25 interview transcripts, 23 contained data pertinent to this question. In this analysis no distinction was made between different types of teaching approach such as lectures, tutorials, assignments, etc.

Analysis of the transcripts revealed three hierarchically inclusive categories of understanding of success. They are, in order of increasing sophistication:

- Success experienced as a perception
- Success experienced as delivery
- Success as developing student thinking

These three categories are discussed in greater detail in the following three subsections.

4.1 Success experienced as a perception

When experiencing success as a perception, the IT teacher has an intuitive feeling about successful teaching. Success is experienced as strongly connected to affective perceptions: either what teachers feel, or what they think or imagine that the students feel. At this level of understanding, teachers focus on their own perceptions about their teaching. Often the teachers' comments about these perceptions are expressed in the context of explaining difficult IT concepts.

"I think I have to say that I've come off most of my lectures fairly happy with the way it went." (E3)

"I suppose that a lecture that I've particularly enjoyed giving would probably qualify as one that I felt was most effective, wouldn't I?" (E2)

"It can be the way you've said it, or the material somehow resonated with their knowledge or their point of knowledge or their point of awareness at that particular point in time and somehow it allowed them to make that next step during the class and if that happens that's wonderful, you really get a positive feeling out of that …" (T2)

4.2 Success experienced as delivery

When experiencing successful IT teaching as delivery, the teacher distinguishes good delivery as an essential component of success. Not only does the teacher feel good about the teaching experience, he or she explicitly mentions the importance of a well-organised or effectively delivered lecture. Sequencing, or telling a good story, is seen as an illustration of successful teaching, supporting the belief that the discipline is sequential in nature. A well-organised presentation is linked to student satisfaction or perceived feelings of happiness.

"I try to concentrate on one theme. And then I talk through the theme, if it doesn't take the 90 minutes, that's totally fine. If it takes more than 90 minutes, that's a situation I try to avoid so... they don't get too tired and too hungry. But I'd like to see one theme, one lecture." (J1)

"Well, an effective lecture was just … demonstrating how to go from a static web page to a dynamic web page. Just being able to demonstrate the elements that have extra tags that, you know, this tag will invoke this, another program which gets all this data. So you can do that fairly simply." (D1)

Delivery encompasses more than sequencing and organising the presentation of topics. Some transcripts indicate a need for abstract thinking and synthesis.

"Okay, I guess it might be, after we discuss the concepts I like to show them some small programs of how we can implement those concepts. I once had this experience when I tried to be too ambitious that I showed them a program that had too many lines of code. I felt at the end of the day that I hadn't actually achieved what I set out to achieve, because I think I lose probably more than half of the class, in the sense that they can't follow those codes. I guess it would be more effective if I'd left the coding, the understanding of the coding to the students but to discuss more on the concepts rather than pay attention to the coding of the program." (F1)

In this conception, good, inspiring demonstrations or examples are perceived as successful IT teaching.

"Basically all fairly similar, but I think it's good when I can provide a key example that encapsulates all of the concepts being considered, and I use that example well. ... They have a concrete idea of how it works that they can abstract from and build upon." (R1)

"In general, the ones I think work better are ones where there is a fairly practical content, ones where students can actually perceive, if you like, an actual real-world application … There's one part of a lecture where I talk about a famous, if you like, disaster in computer programming back in the 60's where a probe that was sent to Mars missed, it went off-course, it never made it; and the reason that it didn't was because of a … basically a fault in programming language design. It wasn't so much a fault in the program that was written but it was in the design of the language … That little bit is fun to explain and students really cotton onto it. And it's not a unique example … the bad design features of languages and so on are really fun to talk about and they're ones that the students can really relate to. … So concrete examples that are really clear and they can see the relation between the concrete example and the principle I am trying to talk about, they seem to work really well, and you get attention, they're really focused on it, and they get something out of it." (L1)

Teachers who 'own' the subject matter express confidence that their delivery is successful:

"Any material I produce rather than from the textbook, actually I feel very confident. And when I deliver I always I feel it is actually much better than the contents provided by the textbook. Because I would I say that I know the aim, why I put in this document? And I also know what I want to achieve through this tutorial." (F2)

In this category successful teaching is still experienced as a perception, but in addition teachers see specific techniques as essential to successful IT teaching. Examples must be well chosen and well explained; success looks a particular way; the story must be told well and the successful teacher knows how to do this.

4.3 Success as developing student thinking

When experiencing success as developing student thinking, IT academics understand successful teaching as inspiring students to engage in their own learning and express their own intellectual curiosity. Success is perceived in active engagement of the student, a goal that is actively pursued in the classroom. Successful teaching is conceptualised as enabling students to understand and synthesise materials so as to form their own opinions, make new connections, and apply their learning in new situations.

"That they've thought, and formed some opinions about a specific topic. That they have been able to synthesise the material that they've found related to that topic into some kind of conceptual framework. That they can then explain." (E1)

"Yeah, they got it straight away. A few of them went and wrote code, and counted the number of operations, to verify for themselves, but they really seemed to get it. … At the end of workshop they were telling me 'We saw the different complexities of sorting algorithms'. That's how you know it works." (M1)

"[The students] can pull it apart, and then say 'yes, I can do that', and they can take it to a parallel but similar situation and implement it. It's not something that they could just copy mine and paste in; it's something they would have to design themselves, because it's only a similar environment, and I think, you know, to get that sort of thing up and running would be highly effective; they really would have a skill that would be worthwhile, and it had been done at a fairly modest cost... A very valuable skill has been developed, and they can then apply it to other, similar, environments in their – when they get out working." (E3)

In this view, student engagement, synthesis and extrapolation of knowledge do not stand alone; they start with effective delivery of materials:

"So they would have been given three things by the time they get out of the lecture: they would have been given a basic philosophy, they would have been given details of how you implement that philosophy in a particular set of tools, and they would have been given a demonstration on how to do that, and they would also have the backup notes with the screen shots. I would then expect them to be able to transfer that knowledge, to be able to apply it to a parallel but similar situation, which is their main assignment." (E3)

This third conception encompasses the two previous ones while adding one further aspect. Here teachers also put value on the extent to which student thinking is perceived to have developed, and whether they can see the students applying and synthesising their newly acquired knowledge and skills.

4.4 Relationship to Prior Work

There is a strong correspondence between Fox's teacher-oriented transfer and shaping theories and our category of successful teaching perceived as delivery. Well-organised lectures clearly fall into the transfer category, but teacher observations on well chosen real-world examples and demonstrations reveal a desire to go further and shape student understanding.

Fox's travelling and growing conceptions are both included in our category of success as developing student thinking. Here the focus is clearly on the student: teachers experience success when students learn independently or synthesise and apply learning to new situations.

Although there is no correspondence between Fox's theories of teaching and our category of success experienced as a perception, our other categories robustly support similar analyses reported in the literature.

5 Group 3: Motivation

A third group analysed the transcripts for academics' understandings of motivating the students.

The psychological literature on motivation is massive, so why study motivation again using phenomenography? A phenomenographic analysis of teacher's conceptions of motivation complements the psychological literature. Psychology is concerned with an objective reality of engagement and motivation, whereas a phenomenographic study is concerned with teachers' subjective experience of it.

Unlike the results from other groups, the four understandings identified were constructed with Fox's categories in mind. The four understandings are:

- Transfer: motivation as coming from the lecturer
- Shaping: motivation as something to be developed within the student
- Travelling: motivation as something determined by the journey's path
- Growing: motivation as something to be cultivated within and by the student

These four categories are discussed in greater detail in the following four subsections.

5.1 Transfer: motivation as coming from the lecturer

Some interviewees discussed how the lecturer's level of engagement affects student engagement:

> *"… obviously having a personal relationship with that topic helps [in teaching]. So if you're digging into your own experiences and coming up with good examples, then I think that helps." (T2)*

> *"The [lectures] that are more effective are the ones that I'm interested in. …" (E1)*

5.2 Shaping: motivation as something to be developed within the student

In this understanding, motivation forms in the student, but under the clear guidance of the teacher.

> *"I don't stick to a rigid structure. I go in and I play by the ear even though I might want to achieve. I give them a weekly schedule at the start of the semester and it is quite a fluid one in the sense that only gives them a guide as to how we are going to progress throughout the semester. But if I feel that students need to spend more time in understanding certain concepts in the topics, I will then do it." (F1)*

> *"I find that those assignments that use games and animations and so on, with the proper specs built into the assignment, the students are actually more motivated to finish off the assignment … that also gives room for creativity and imagination, because they may have animation, they may have, you know, colours, they may have multimedia or included in part of submission." (F1)*

5.3 Travelling: motivation as something determined by the journey's path

Understanding Fox's travelling as a journey through the countryside of discipline knowledge, motivation can be found in the use of local distractions that highlight aspects of the landscape.

> *"It seems the most effective lecture I had this last semester is when I walked in and almost off the top of my head designed a database that would store information about what was then the ashes series going on in England in the cricket – England versus Australia. … I talked about constructing a database to store the results. It was remarkable how some of them really lit up, and enjoyed that example..." (N1)*

5.4 Growing: motivation as something to be cultivated within the student

In this excerpt, motivation begins in the shaping category, then shifts to growing as the students begin to motivate themselves.

> *"They would come back and 20% of them would have done it and some of them didn't do it because they didn't understand it and the rest didn't do it because they just weren't motivated. I found that where we worked together on the board they actually got into it – they saw that ah this isn't so bad after all – and once they started seeing if we took them through some … you work on a simple problem then you add just a little bit to the next one and a little bit to the next one they go to the point where they liked to achieve and they could [see] that they could do it, and they were almost getting competitive." (I2)*

5.5 Relationship to previous work

As discussed above, these four understandings were formed with Fox's personal theories in mind. Some phenomenographers suggest that the search for categories should be carried out with absolutely no preconceptions, but this would appear to be all but impossible for a researcher who is familiar with the area being studied. We take this result to suggest that our transcripts can be seen as supporting the long-established categories.

6 Group 4: Granularity of focus

This group did not look at a specific aspect of IT teaching but instead at the broad perspective of the teachers' understandings of their teaching. The categories of description that emerged define the focus that educators have for their teaching work:

- Focus on subject
- Focus on course
- Focus on employment at graduation

- Focus on career
- Focus on life and society

These five categories are discussed in greater detail in the following five subsections.

Each category describes a framework that scopes and directs how the teachers plan, design, and implement their teaching program and activities. A fine-grained focus, on individual subjects, tends to correspond with short-term goals for students, while a coarse-grained view, on the rest of the students' lives, looks at the far longer-term goal of developing lifelong learning capability.

6.1 Focus on subject

When understanding IT education as focusing on the subject, the educator is concerned primarily with teaching content. The educator's focus is directed towards helping the students gain the skills and knowledge to complete the subject successfully.

> *"The aim of the subject is to get the student to understand, as the title says, Web technology …" (D1)*

6.2 Focus on course

When understanding IT education as focusing on the course (the full program of study leading to a qualification), the educator is aware of the content of other subjects within the course. The educator's focus is on ensuring that students gain the necessary knowledge and skills to progress through the course. The educator is also sensitive to what students may have studied or are concurrently studying in other subjects within the course.

> *"… there are a number of outcomes ... the immediate outcome is that they can succeed and progress with the following [subject] because this is a prerequisite for a number of [subjects] ..." (O1)*

6.3 Focus on employment at graduation

When understanding IT education as focusing on employment, the educator is concerned with preparing students for the workforce. The focus is on ensuring that students are able to gain employment in computing and to work effectively immediately after graduation. The focus here is on the presentation of content that is current and relevant. This also involves designing activities to develop skills that will be useful to students in the workplace.

> *"Knowing the features of different languages – the faults and good bits – means that when they are out in the workplace and they have to choose a language for a project then they are better equipped to choose the language, the best language for the job." (L1)*

6.4 Focus on career

When understanding IT education as focusing on the career, the educator endeavours to prepare students for lifelong work in a range of careers and workplaces. The focus is on helping students develop attitudes and approaches to learning that will help them evolve and adapt as needed throughout their working life. The educator is concerned with linking subject content to the issues the students will encounter in their future employment.

> *"… you have to learn to adapt to continuous change and so we do not know at the moment what will happen after a few years on …" (K1)*

6.5 Focus on life and society

When understanding IT education as focusing on life and society, the educator is concerned that students understand the role of the IT profession in society and

<table>
<tr><th></th><th>Fox (1983)</th><th>Practicals (sec 3)</th><th>Success (sec 4)</th><th>Motivation (sec 5)</th><th>Focus (sec 6)</th></tr>
<tr><td rowspan="2">Content- or teacher-centred
Positivist
"Sage on the stage"</td><td>Transfer: teacher-driven learning with focus on content</td><td>Acquire and practice skills</td><td rowspan="2">Delivery</td><td>Coming from lecturer</td><td rowspan="2">Fine grain, short-term goals</td></tr>
<tr><td>Shaping: teacher-driven learning with focus on student change</td><td>Reinforce learning from lectures and/or textbook</td><td>Developed within student under lecturer's guidance</td></tr>
<tr><td rowspan="2">Student-centred
Constructivist
"Guide on the side"</td><td>Travelling: student-driven learning with focus on content</td><td>Refine and troubleshoot acquired skills</td><td rowspan="2">Develop student thinking</td><td>Determined by the journey</td><td rowspan="2">Coarse grain, long-term goals</td></tr>
<tr><td>Growing: student-driven learning with focus on student change</td><td>Apply skills acquired elsewhere</td><td>Cultivated within student by student</td></tr>
</table>

Table 1: The results of four groups compared with Fox's personal theories of teaching

consider how the technology influences various aspects of life.

> *"Telecommunications are nowadays more and more everyday life for students ... I think it is quite essential that they understand those problems and chances that are included in telecommunications." (K1)*

6.6 Relationship to Prior Work

We are not aware of any prior research that has considered this question of granularity of the academic's focus. We do find a possible link with Fox's broader categories: a fine-grained focus and a short-term teaching goal appear to correspond with teacher- or content-centred categories, while the coarser-grained focus and longer-term goals appear to correspond with the student-centred categories.

7 Conclusion

There has been some earlier phenomenographic research on the experience of teachers within various disciplines, but the experience of computing teachers has until now remained relatively unexplored.

We have conducted broad-ranging interviews with 25 computing academics to elicit the different ways that they understand their teaching. Our preliminary analysis of the transcripts took place at a workshop to introduce computing academics to phenomenography, and in the following weeks the four groups from the workshop continued their analysis, guided by the workshop's leaders.

For the most part unaware of Fox's personal theories of teaching, most groups produced results that are reasonably consonant with those theories (see Table 1). At the same time, the results include some observations that do not appear to have appeared in prior work, such as the question of granularity of an academic's focus and the corresponding time span of the academic's goals for the students.

This project contributes to the broad educational community by illustrating how educational research can be fertilised by the questions and results of non-educationalists. Results from computing education become accessible to the wider community, including educationalists. In addition, the study further confirms Prosser's suggestion that analysis of this sort is highly context-dependent, and adds one more discipline to the tally of those studied.

The contributions to the computing education community are perhaps more concrete. First, the study offers computing academics an insight into the understandings that underlie their teaching. Second, an awareness of these understandings can help by providing a framework for the analysis of proposed teaching methods and materials.

When debating the construction or revision of a subject or degree, it is our contention that a group of IT academics will function better as a team if they are explicit about the beliefs and values that lie behind their individual positions. More specifically, they should place their statements into the context of the categories that have emerged from our study. They should ask themselves questions such as the following:

1. Do we want any lab practical classes to be classes in which students
    - acquire and practice skills that are more or less independent of the lectures?
    - reinforce material presented in lectures and/or textbooks?
    - refine and troubleshoot skills that they have acquired elsewhere?
    - apply skills that they have acquired elsewhere?
2. Will we determine the success of this course
    - by the way it feels, either to us or to the students?
    - by the quality of delivery of the teaching material?
    - by evidence of development of student thinking?
3. Do we expect the student motivation for this course
    - to come from the lecturer?
    - to be developed within the student under the lecturer's guidance?
    - to be determined by the student's journey through the subject matter?
    - to be cultivated within and by the student?
4. Are our goals for the students in this course
    - fine grained, focused on the subject or the course?
    - coarse grained, focused on the student's career prospects or role in society?

We do not argue, as one might when studying student understanding of a topic in computing, that the higher-level categories are necessarily the best or the most appropriate for all circumstances. We suggest only that academics who are aware of the range of understandings will be better able to decide how to design a revision or a new offering.

We believe that our work demonstrates that research of this type can bring valuable insights. We hope that others will follow us in applying this research approach to problems in the teaching and learning of computing.

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9 References

Åkerlind, G (2005): Phenomenographic methods: A case illustration. In J. Bowden & P. Green (Eds.), *Doing Developmental Phenomenography*, 103-127. Melbourne, Australia, RMIT University Press.

Ben-Ari, M (2001): Constructivism in Computer Science Education. *Journal of Computers in Mathematics and Science Teaching* **20**(1):45-73.

Berglund, A (2005): Learning computer systems in a distributed project course: the what, why, how and where. *Acta Universitatis Upsaliensis*, Uppsala, Sweden.

Booth, S (1992): *Learning to program: a phenomenographic perspective*. PhD thesis, University of Gothenberg, Sweden.

Booth, S, & Ingerman, A (2002): Making sense of physics in the first year of study. *Learning and Instruction* **12**(5):493-507.

Bruce, C, Buckingham, L, Hynd, J, McMahon, C, Roggenkamp, M, Stoodley, I (2004): Ways of Experiencing the Act of Learning to Program: A Phenomenographic Study of Introductory Programming Students at University. *Journal of Information Technology Education* **3**:143-159. http://jite.org/ documents/Vol3/v3p143-160-121.pdf [accessed October 2006]

Carbone, A, & Kaasbøll, J (1998): A survey of methods used to evaluate computer science teaching. *Proc 3rd Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE)*, Dublin, Ireland, 41-45, ACM Press, New York.

Cope, C (2000): Educationally critical aspects of a deep understanding of the concept of an information system. *Proc Fourth Australasian Computing Education Conference (ACE2000)*, Melbourne, Australia, 48-55.

Dunkin, M (1990): The induction of academic staff to a university: processes and products. *Higher Education* **20**:47-66.

Eckerdal, A & Berglund, A (2005): What Does it Take to Learn "Programming Thinking"? *Proc 1st International Computing Education Research Workshop (ICER'05)*, Seattle, WA, USA, 135-142. ACM Press, New York.

Eckerdal, A, & Thuné, M (2005): Novice Java programmers' conceptions of "object" and "class", and variation theory. *Proc 10th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education (ITiCSE)*, Caparica, Portugal, 89-93, ACM Press, New York.

Fox, D (1983): Personal Theories of Teaching. *Studies in Higher Education*, **8**(2):151-163.

Kutay, C, & Lister, R (2006): Up close and pedagogical: computing academics talk about teaching. *Australian Computer Science Communications* **52**:125-134.

Leveson, L (2004): Encouraging better learning through better teaching: a study of approaches to teaching in accounting. *Accounting Education* **13**(4):529-548.

Lister, R, Box, I, Morrison, B, Tenenberg, J, Westbrook, S (2004): The Dimensions of Variation in the Teaching of Data Structures. *Proc 9th Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE)*, Leeds, UK, 92-96, ACM Press, New York.

Marton, F (1986): Phenomenography − a research approach to investigating different understandings of reality. *Journal of Thought* **21**:28-49.

Marton, F, & Booth, S (1997): *Learning and Awareness*. Mahwah, NJ, USA: Lawrence Erlbaum Associates.

McKenzie, J (2002): Variation and relevance structures for university teachers' learning: Bringing about change in ways of experiencing teaching. *Research and Development in Higher Education* **25**:434-441.

Northedge, A (1976): Examining our implicit analogies for learning processes. *Programmed Learning and Educational Technology* **13**(4):67-78.

Pang, M-F & Marton, F (2003): Beyond "lesson study": comparing two ways of facilitating the grasp of some economic concepts. *Instructional Science* **31**(3):175-194.

Prosser, M, Trigwell, K, Taylor, P (1994): A Phenomenographic Study of Academics' Conceptions of Science Learning and Teaching. *Learning and Instruction* **4**:217-231.

Ramsden, P (2003): *Learning to teach in higher education* (2nd ed.). London; New York: Routledge.

Runesson, U (2005): Beyond discourse and interaction. Variation: a critical aspect for teaching and learning mathematics. *Cambridge Journal of Education* **35**(1):69-87.

Samuelowicz, K, & Bain, J (1992): Conceptions of teaching held by academic teachers. *Higher Education*, **24**:93-111.

Simon, de Raadt, M, Sutton, K, Venables, A (2006): The unique role of lab practical classes in computing education. *Proc 6th Baltic Sea Conference on Computer Education Research (Koli Calling 2006)*, Koli, Finland.

Stoodley, I, Christie, R, Bruce, C (2004): Masters Students' Experiences of Learning to Program: An Empirical Model. *Proceedings of QualIT2004: International Conference on Qualitative Research*. http://sky.fit.qut.edu.au/~bruce/pub/papers/QualIT2004-Bruce.pdf [accessed October 2006]

Trigwell, K, Prosser, M, Taylor, P (1994): Qualitative differences in approaches to teaching first year university science. *Higher Education* **27**(1):75-84.