

University teachers' experiences of change in their understanding of the subject matter they have taught

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This paper reports an analysis of qualitatively different ways in which teachers experience change in their understanding of subject matter they have recently taught. In this exploratory study, interviews with 31 'typical' teachers from a range of first and second-year university subjects revealed that 20 reported no experience of change in their understanding. The reports of the 11 teachers who did experience change were used in a phenomenographic study from which five qualitatively different categories of description of change were constituted. These range from the experience of change as the adding of unproblematic knowledge to what is already known, to questioning the theoretical framework of the subject matter. The relation between the experience of change in understanding and the experience of teaching and learning for the 31 teachers was also explored. It was found that the teachers who did not experience change in their understanding were more likely to experience teaching as the transmission of knowledge, and the teachers who experienced change in their understanding, and who experienced that change as the re-interpretation or questioning of knowledge, were more likely to experience teaching as changing or developing students' conceptions.

Introduction

All teaching is a form of translation from the subject at the cutting edge of knowledge to the subject as comprehended by a good teacher; from the subject as comprehended by a good teacher to that as comprehended by a student, with due differences to allow for different development stages of the student. There is always 'Loss in Translation', . . . but . . . there are also gains. Similarly, there can be gains in trying to translate our knowledge so that it becomes accessible to our students: it frequently makes us understand our knowledge at a deeper level, the basis for the well known saying that there is no better way to learn something than to teach it. (Elton, 2000, p. 259)

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This paper reports an analysis of teachers' experience of change in their understanding of the subject matter they have recently taught.

Recent research on teaching in higher education has focused on how university teachers approach the teaching of their subject matter, their conceptions of the teaching and learning of their subject matter, and their perceptions of the environments in which they teach (Samuelowicz & Bain, 1992, 2001; Kember & Gow, 1994; Trigwell & Prosser, 1996; Martin & Ramsden, 1998; Prosser & Trigwell, 1999; Kane *et al.*, 2002; Trigwell & Prosser, 2003).

Qualitatively different experiences of teaching (ranging from one in which the teacher's intention is to transfer information, to one in which the intention is to change students' conceptions and understandings) have been found to be related to variation in teachers' experiences of leadership in teaching (Martin *et al.*, 2003), to variation in their experience of what it is that should be constituted for students to learn (Martin *et al.*, 2000), and to variation in their understanding of the subject matter they are teaching (Prosser *et al.*, in press). Relations have also been identified at the departmental level between teachers' approaches to teaching and their students' approaches to learning (Gow & Kember, 1993). And students in the classes of teachers who adopt an approach based on the intention to transmit information are more likely to use surface approaches to learning than students in the classes of teachers whose intention is to develop understanding (Trigwell *et al.*, 1999).

Much of this research is aimed at describing and analysing the relationships between qualitatively different aspects of teachers' awareness of their teaching/learning situation. There is very little research that has focused on describing the outcomes of teaching (for outcomes other than the quality of student learning). Developing a more complete understanding of teaching and of ways of improving teaching may be assisted by addressing issues of how teachers experience the outcomes of their teaching and how these experiences relate to the way they teach their subject matter. An important outcome of teaching is the experienced change in the teachers' understanding of the subject matter being taught. This is the subject of this paper.

In an earlier study of relations between academics' understanding of their subject matter and their teaching (Prosser *et al.*, in press), we looked again at the structure of the variation of the teachers' experience of teaching and learning that we first reported for university science teachers (Trigwell *et al.*, 1994). Table 1 shows how the five categories of experience found for a group of teachers from a range of disciplines are related through structural and referential components of that experience. The set of five qualitatively different categories of how approaches to teaching are experienced is described below:

- *Experience A*: Teacher-focused, teacher activity with the intention of transferring information to the students. This approach is one in which the teachers adopt a teacher-focused strategy with the intention of transmitting information about the discipline. They presume that students do not need to be active in the teaching/

Table 1. The structure of the qualitative variation in five categories (A–E) of teachers' experience of teaching and learning

Referential	Structural		
	Teacher-focused		Student-focused
	Teacher activity	Student activity	Student activity
Information transfer	A	B	
Concept acquisition		C	
Conceptual development			D
Conceptual change			E

learning process. The focus of activity is on the teacher demonstrating discipline-based facts and skills.

- *Experience B*: Teacher-focused, student activity with the intention of transferring information to students. The teachers adopt a teacher-focused strategy with the intention of transferring information to students. They presume that students *do* need to be active in the teaching/learning process, but the focus of the designed activity is on the teacher disseminating discipline-based information with an understanding that different dissemination strategies will assist students to understand the material.
- *Experience C*: Teacher-focused, student activity with the intention that students will acquire the concepts of the discipline. The teachers adopt a teacher-focused strategy, with an intention which goes beyond transfer to helping students to acquire the concepts of the syllabus. The focus of activity is on building students' understanding of the subject matter through working within the predetermined disciplinary framework structures and introducing student activity around these structures.
- *Experience D*: Student-focused, student activity with the intention that students develop their own conceptions. The teachers adopt a student-focused strategy with the intention of assisting students to develop their own conceptions of the subject matter. The focus of student activity is on elaborating and extending students' understanding of the subject matter by employing discipline frameworks of concepts in tasks in which the framework is seen as a resource.
- *Experience E*: Student-focused, student activity with the intention that students change their conceptions. The teachers adopt a student-focused strategy with the intention of helping students change their conceptions of the phenomena they are studying. The focus of student activity is on students restructuring their current world view by interacting with subject material in a way that challenges their currently held conceptions, so that they restructure and change these conceptions.

In recent research we have identified a close empirical relationship between teachers' experience of teaching and learning as described above, and their experience of understanding the subject matter they teach (Prosser *et al.*, in press).

Teachers who experienced teaching as being student-focused and aimed at conceptual change or development (experience D or E) were more likely to describe an integrated and broader-ranging focus on concepts and theories in their understanding of their subject matter. Teachers who experienced teaching as being more teacher-focused and aimed at transmission (experience A–C) were more likely to describe a fragmented, atomistic understanding of their subject matter.

These analyses yield results that are of use in educational development, but they do not address questions of the outcomes of university teaching. For the topic of the present study we asked the same teachers additional questions about their experience of *change* in their understanding of their subject matter after having taught the subject. A change in understanding is one way of representing an outcome of teaching for the teacher. The variation in the experience of change and the relations between change and experience of teaching are the subject of this paper. We hypothesise that where teachers experience their teaching as being more teacher-focused with transmission intentions, they will be less likely to experience a change in their understanding of the subject matter they are teaching.

Method

A total of 31 teachers from the major disciplinary fields (Business and Law, Health Sciences, Humanities and Social Sciences, and Science and Engineering) were interviewed as part of a study of their experience of understanding of their subject matter, of teaching, and of the object of study for students (Martin *et al.*, 2000; Prosser *et al.*, in press). That sample was selected to:

1. maximise within-field variation in approaches to teaching (i.e. teachers adopting information transmission and conceptual change approaches were represented);
2. ensure that the teachers were engaged in the teaching of a topic or subject extending over at least one semester of study for first or second year students; and
3. ensure that the teachers had more than one year of experience in teaching the topic in which their change in understanding was being investigated.

No attempt was made in selecting this sample to ensure that teachers had experienced a change in their understanding of their subject matter or that they were the most likely to experience change (for example, ‘first time’ teaching), as we were also interested in the extent to which an experience of *no-change* in understanding was described.

Each teacher was interviewed, in depth, prior to their teaching of a chosen topic and again at the end of it. The interviews were transcribed and analysed rigorously using analytical procedures developed previously for similar phenomenographic studies (Marton, 1981; Marton & Booth, 1997; Bowden & Walsh, 2000). The analysis was conducted in three stages. The aim of the first stage was to identify the categories of description of the qualitative variation in three aspects of the teacher’s

experience: the object of study they constitute for their students, teaching and learning and their understanding of the subject matter. The second stage was focused on the experience of change in understanding. Only the second interview (at the end of the teaching session), which contained a question specifically on the teachers' experience of change in their understanding of their subject matter, was used in this stage, and from it, transcripts describing an experienced change were separated from those that did not. The third stage, the identification of the variation in experiences of change, involved several sub-stages—an initial identification of a set of categories of description, based upon reading a subset of the full set of transcripts; analysis of the structural relationship between the categories independently of the transcripts; and an iteration between the transcripts and the structural relationship, until a stable set of categories was constituted. These categories were then used to classify all the transcripts, with some subsequent adjustment to the categories and their structure to ensure that they captured the full variation represented in the 11 transcripts.

Results

Relations between change/no-change and experience of teaching and learning

All 31 teachers interviewed described their experience of teaching and learning and their understanding of the subject matter they had recently taught to students. All were asked about their experience of change in their understanding of the subject matter; only 11 described an experience of change following the teaching process.

The transcripts from individual teachers that had been allocated to an experience of teaching and learning using categories A–E described above, were cross-tabulated with their allocation to a change- or no-change-in-understanding-of-subject-matter category (Table 2). A transmission approach (A–C) was described by 21 teachers, and a conceptual change/development approach (D or E) by 10 teachers.

Table 2 shows a moderate and statistically significant relationship between the experience of change and the experience of teaching and learning. (The size and statistical significance of the relationship was tested using Somers' *d*—a test of relations between ordinal level data. The size of the relationship is measured directly. A Somers' *d* of more than .70 suggests a strong relationship, .30 to .70 a moderate relationship, and less than .30 a weak relationship.) Of the 31 teachers in the study, 20 reported no experience of change in their understanding of the subject matter they had just taught. Of these 20, 16 described their experience of teaching as having an information transmission or concept acquisition intention combined with a teacher-focused strategy. Only four described an intention to change or develop students' conceptions. This distribution is in contrast to that of the 11 teachers who described a change in their understanding of the subject matter. In this case 6 of the 11 reported a focus on students' conceptual change or development and described using student-focused strategies. This distribution describes a moderate relationship between experience of teaching/learning and change in understanding of subject matter.

Table 2. Relations between experience of change in understanding of subject matter and experience of teaching/learning for 31 university teachers

Experience of teaching and learning	Experience of change in understanding of subject matter		Total
	No change	Change	
A		1	1
B	6		6
C	10	4	14
D	4		4
E		6	6
Total	20	11	31

Somers' $d = .387$, $p = .016$.

Outcomes of the phenomenographic study

Table 3 shows the constituted outcome space of the phenomenographic study of the experience of change in understanding of subject matter. In the development of the structural component, elements of the Structure of the Observed Learning Outcome (SOLO) Taxonomy (Biggs & Collis, 1982) were used. The SOLO Taxonomy describes five levels of outcome. The first level is Pre-structural where an outcome contains nothing of relevance to the knowledge in question. The second level is Uni-structural, and includes outcomes where there is a reference to only one relevant item. Multi-structural outcomes are those where more than one relevant item is included, but those items are listed independently rather than in a related way.

Table 3. Teachers' experience of change in their understanding of their subject matter

Structural	Referential				
	Quantitative adding of unproblematic knowledge	Reorganisation of unproblematic knowledge	Reorganisation of problematic knowledge	Reinterpretation of problematic knowledge within a theoretical framework	Questioning/ further development of a theoretical framework
Multistructural topic	<i>A</i>				
Relational subject		<i>B</i>	<i>C</i>		
Extended abstract field				<i>D</i>	<i>E</i>

Outcomes of a Relational (level four) nature do not necessarily include a greater amount of knowledge than in the case of Multi-structural outcomes, but the understanding is integrated and related, and the separate elements are described as part of an overall structure. The final, and most complete level (Extended Abstract) includes those outcomes that demonstrate the generalisability of the related understanding to new contexts. Students with this understanding are able to draw upon it in (some) new contexts.

Five qualitatively different ways of experiencing change in understanding of the subject matter were constituted from the 11 transcripts in which teachers described an experience of change. Each of the five categories of description, and how it differs from the others, is presented below, with some quotes from transcripts. Because the categories are constituted from the pool of transcripts, a quote may not represent the full category of description.

Experience A. Change is experienced as an addition of unproblematic (or taken-for-granted) knowledge to what is already known. The focus of awareness is on changes at the multi-structural (rather than relational) level within the topic, and the experience of change is of acquiring new elements of content knowledge, and treating the new knowledge as additional unproblematic knowledge, which is largely independent of what is already known.

I found out lots of things about more efficient methods of making sand cores. Sand cores are things that make internal cavities in metal castings; how you more efficiently make those and ... some machinery and use of CO₂ gas to actually cure the casting ... so that was interesting, interesting for my benefit. The students learnt something, I learnt something and hopefully I'll also pass that on for subsequent years, build that into the curriculum. ... As a whole I don't think [my understanding of the subject has] actually changed ... Only segments of the technology has changed.

So therefore I'm finding that I'm stretching my abilities of the sorts of manufacturing techniques you can use to make the designs, which is quite interesting. But I don't think it actually stretches my understanding of higher technologies. It's only adaptations of different technologies and incorporating it and assisting them to understand those.

Experience B. Change is experienced as a reorganisation of unproblematic knowledge. The focus of awareness is on changes within the subject that are relational. The experience is of reorganised aspects of content knowledge that are part of a coherent whole (module or subject) though that coherence is externally constituted, such as in a defined curriculum or good textbook.

There were actual elements of the subject which I felt were important to introduce this year which I didn't introduce in quite the same way in previous years. So I guess you could say yes, it did change my understanding, in that I've had to re-alter my thinking about some things, yes.

It doesn't change the overall substance of the subject. In one area of the content of the subject, I've changed the emphasis on what was being taught, and in doing so I think I've come across, having to pick up a bit of knowledge which I needed to do.

Experience B differs from Experience A in that knowledge is reorganised rather than just added to and the focus of the experience is on the subject as a whole rather than individual elements or topics within the subject.

Experience C. Change is experienced as a reorganisation of problematic or contestable knowledge. The focus of awareness is on change at the relational level within the subject. The experience is of a change to a new and coherent whole, which is internally constituted (by the individual teacher).

I've certainly discovered ways of thinking about them and seeing relationships in a way which makes them easier to communicate. Yeah I guess that I understand the concepts better myself, particularly since this year we've developed two teaching aids which are helpful in explaining that. And I think the development of those teaching aids has come upon a better understanding ourselves. I mean it didn't occur to us to produce these teaching aids previously, and that's probably because we didn't understand the concepts as well as we do now.

One of the teaching aids we developed is a series of ... it's like a clock dial type device. And I guess the discovery that we could actually, on this device, represent all of the motions that we wanted to represent was quite illuminating. We hadn't previously thought that we could do that and it more or less came over a period of a week or two that we could do that. It was quite illuminating.

Experience C differs from Experience B in that knowledge is seen as being problematic or reworkable rather than unproblematic or given, hence the new knowledge is constituted by the individual rather than via a curriculum or textbook. As in Experience B the focus of the experience is on the subject as a whole.

Experience D. Change is experienced as a reinterpretation of problematic knowledge. This experience is conceptualised at a theory-based higher level of abstraction within the wider field of the subject matter. The focus of awareness is on the reinterpretation of content knowledge in relation to a theoretical position but the change, while involving reinterpretation, does not challenge the teacher's existing theoretical framework.

So that kind of Great White Men national history I think we have assumed to be there. So I have, I think, shaped my teaching to challenge and overcome that history. If it's not there, then what I'm doing doesn't make much sense. And I feel that I therefore have to teach that history as well, in a way, that I have to teach the narrative against which I am working in a sense. So my understanding of the subject, both pedagogically but also as a way of representing Australian history, I think is changing, and will change as a result of my experience this semester as well as in previous years.

Well yes, in so far as I think that that pattern that I had in my head that was very much, was very solipsistic because, in fact, I don't know how relevant this is, but because it's a very specialised area. There actually isn't anyone around here who I talk to, really, about this material. So what I thought was very clear in my head, now doesn't seem quite as clear. I mean if you're saying 'Has teaching this topic made me feel more on top of it?', the reverse is more the case. I think it's actually made me feel, I hope productively, less sure of myself.

Experience D differs from Experience C in that knowledge is reinterpreted rather than just being reorganised, and that the teacher's focus goes beyond the individual subject to the field as a whole, or to the areas of study encompassed by the relevant theoretical framework.

Experience E. Change is experienced as the questioning and further development of a theoretical framework within the field in which the knowledge is constituted. The focus of awareness is on rethinking a theoretical framework.

... I felt last year a bit uneasy about the course, because I think of it as rather a soft subject, very different to the other kinds of subjects that I teach. And I was a bit concerned that there really isn't enough kind of intellectually meaty material. I feel less concerned about that this year than I did last year and that's partly because I began to see something that was really philosophically useful in some of the activities I had with students.

... I suppose I'm coming increasingly to think of Philosophy with Children as a kind of large-scale educational reform than I used to. I used to think of it as something that would be good for kids to do, ... that would improve their performance in other subjects ... I'm starting to think of it in a slightly more grandiose way as really potentially part of a larger kind of reform in how we think about education ...

Experience E differs from Experience D in that in E the theoretical framework within which knowledge is constituted is problematised rather than the knowledge itself. As with Experience D, the focus of awareness is on the field as a whole.

Relations between the change and teaching variables for individual teachers who experienced change

Table 4 shows an analysis of the relationship between the teachers' experience of change in their understanding and, from the same interview transcript, their experience of teaching and learning. It shows a strong and statistically significant relationship between the two variables. Only three of the categories of experience of teaching and learning are described (A, C and E), but they include the extremes of the qualitative variation in experience.

Finally, as a way of exploring any effects that might be due to differences in disciplines, Table 5 shows an analysis of the experience of change in understanding by broad teaching field. Table 5 suggests that there may be variation by field in the data. It indicates that changes in understanding were more likely to occur among

Table 4. Relationship between teachers' experience of changes in their understanding and their experience of teaching and learning for those teachers who experience change

Experience of teaching and learning	Experience of change of understanding subject matter					Total
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	
<i>A</i>	1					1
<i>C</i>		2	2			4
<i>E</i>			3	2	1	6
Total	1	2	5	2	1	11

Somers' $d = .727$, $p = .009$.

Humanities and Social Science teachers. Indeed, all three of those who described an experience of change in understanding categorised as *D* or *E* were in the Humanities and Social Sciences.

Discussion

The majority (20) of the 31 participants interviewed did not describe an experience of change in their understanding. There are strong relations, for these 20 teachers, between their experience of no change in understanding and their experience of teaching/learning. None of the 20 were among the six teachers who described their experience of teaching and learning in terms of a conceptual change, student-

Table 5. Distribution of teachers across the experience of change in understanding categories by teaching discipline

Experience of change of understanding subject matter	Teaching discipline			
	Science and Engineering	Health Sciences	Business/Law	Humanities/Social Sciences
No change	5	8	5	2
<i>A</i>	1			
<i>B</i>	2			
<i>C</i>		1	2	2
<i>D</i>				2
<i>E</i>				1

Chi-square = 23.9, $df = 15$, p (exact) = .019.

focused approach to teaching (experience E). Four described using a conceptual development, student-focused approach (experience D). The remaining 16 (80%) described using transmission/teacher-focused approaches to teaching (experience A–C).

This result is consistent with the hypothesised position that where teachers experience their teaching as being more teacher-focused with transmission intentions, they are less likely to experience a change in their understanding of the subject matter they are teaching. The five qualitatively different ways of experiencing change in understanding of the subject matter being taught were constituted using an interview-based phenomenographic approach. This approach focuses on the aspects of the experience that differ and ignores aspects that the categories may share. The outcome space described in Table 3 is, therefore, a snapshot of different ways of experiencing change in understanding of subject matter.

In the case of the 11 university teachers who described an experience of change, the nature of that change was found to be systematically related to their experience of teaching/learning. When teachers experienced teaching as being aimed at changing students' conceptions (E), they were more likely to describe change in their understanding of their subject matter as involving an awareness of its theoretical framework (D, E). When they saw teaching as the transmission of information using teacher-focused approaches (A–C), they were more likely to describe change as a quantitative adding of unproblematic knowledge to existing unproblematic knowledge (A, B).

There is a suggestion in these results (Table 5) that some of the effects may be due to differences in the teaching disciplinary areas, although the sample size in this study (which is large for studies of this sort) did not allow this to be systematically explored. In our previous studies, we have found transcripts from each of the broad teaching fields distributed across all categories. The distributions across these areas may have varied, but we found at least one transcript from each broad field in each category. In this study we found that it was only in transcripts from the Humanities and Social Sciences that teachers described a questioning of their theoretical framework after having taught the subject. In Science and Engineering, there was no problematising of understanding at all, just some addition of new information. It should be noted that only one of the eight Science and Technology transcripts, one of seven transcripts in Business/Law and three of nine in Health Sciences were classified as teaching and learning experience D or E, while six of the seven Humanities and Social Science transcripts were classified as D or E. In our purposive sampling we attempted to obtain a reasonable spread across the teaching fields, but were less successful than we had hoped in three of the four fields. While there are clearly distributional differences between the broad fields, it is not clear whether the lack of transcripts in certain categories represents field variation or issues of sampling. This issue is one which will need much more systematic analysis in future studies.

In the introduction to this paper, we described change in understanding of the subject matter being taught as an outcome of university teaching. Experience of

change in understanding of the subject matter being taught is more common among teachers who have a more complex experience of teaching and learning (D and E) (6 of 11) than among those with a less complex experience of teaching (A–C) (5 of 21). While this result from such a small sample must be treated with some caution, it is consistent with the results from an independent quantitative study (Trigwell & Ashwin, 2003). In a sample of over 140 teachers from a variety of disciplines and universities they found that when teachers disagreed that they had not learned something during their teaching they were more likely to be reporting higher scores on the conceptual change/student-focused approaches to teaching scale of the Approaches to Teaching Inventory (Trigwell & Prosser, 2004).

While the relations described in this paper cannot be considered to be causal, there is a logical internal relation between teachers' experience of teaching and the outcomes of their teaching. If teachers are simultaneously aware of their approaches to teaching and changes in their understanding of their subject matter, it is conceivable that enhancing the complexity of either may lead to an enhancement of the other. This may have implications for student learning, teacher learning and opportunities for academic development. Qualitative differences in students' approaches to learning are related to qualitative differences in approaches to teaching. Some approaches to academic development have included a focus on conceptions and approaches to teaching (Ho, 2000; Ho *et al.*, 2001) but we are unaware of approaches that consider associated changes in the ways teachers understand their subject matter.

Summary and conclusion

As part of a large study exploring the relations between teachers' experience of teaching and their experience of their understanding of the subject matter that they teach, we have reported in this paper an analysis of qualitatively different ways that teachers' experience *change* in their understanding of the subject matter they have taught. Five qualitatively different categories of description were constituted. They range from the experience of change as a quantitative adding of unproblematic knowledge to what is already known, through re-organisation of knowledge which is problematic, to change as a questioning of the theoretical framework of the subject matter.

It was found that the teachers who did not experience change in their understanding were more likely to experience teaching as being about the transmission of knowledge. The teachers who did experience change in their understanding, where the change was more about re-interpretation or the questioning of problematic knowledge (rather than as the re-organising or adding to unproblematic knowledge), were more likely to experience teaching as student-focused (rather than teacher-focused).

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