

How academics use technology in teaching and learning: understanding the relationship between beliefs and practice

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Abstract

This paper reports on a detailed investigation into the beliefs and practices of teachers in 22 computer-assisted learning projects in Australia in the mid-1990s. Detailed interview data were obtained, supported by the project software and other curriculum materials. The interview transcripts and documentary material were collated and condensed into rich descriptions; these were then coded on a number of belief and practice dimensions. The resulting profiles were clustered into five belief–practice categories: thoughtful instructors, pre-emptive professionals, conversational constructivists, learning facilitators and situated knowledge negotiators. These complex, yet interpretable, patterns of relationships between beliefs and practices are useful in understanding teachers' reluctance to change their teaching, one instance of which is the relatively limited uptake of technology in higher education.

Keywords

belief dimensions, case descriptions, cluster analysis, computer-assisted learning, higher education, practice dimensions.

Why bother with beliefs?

The aim of this research was to investigate the relationships between the design and outcomes of computer-assisted learning (CAL) in higher education and the educational beliefs and practices of the academics who develop and use such technology. The research focused on Australian academics who were 'early adopters' (Rogers 2003) of educational technology and had been successful in obtaining competitive development funding for their projects. Our research was prompted by several observations and questions:

- Like other teaching initiatives, CAL implementations vary considerably in character: Why?
- Many academics resist the use of CAL that has been 'created elsewhere'? Why?
- Academic staff development units often report difficulty in augmenting academics' teaching and learning methods. Why?
- Many academics have adopted Internet-based technologies to support their teaching, but often in limited forms. Why?

Although the answers to these questions are undoubtedly complex, our working assumption has been that a common element among all of them is the educational and epistemological beliefs underpinning academics' teaching, learning and assessment practices. So, to take our first bullet point above, we conjecture that variation in the styles of CAL is attributable – in

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part – to variation in the educational assumptions of those designing it. Similarly, academics are not likely to adopt a teaching resource made elsewhere unless it ‘fits’ with their assumptions about appropriate and viable methods for their content domain.

There is growing evidence for the variety (Kember 1997; Samuelowicz & Bain 2001) and the influence (Ramsden 1992; Hativa & Goodyear 2002; Samuelowicz & Bain 2002) of educational beliefs in the practices of university teachers. One contrast to emerge with some consistency in the literature is between academics who think of learning as reproducing established knowledge (and of teaching as organising and presenting that knowledge appropriately), and others who think of learning as the outcome of an understanding process, which, although assisted by the teacher, has to be constructed by the student (e.g. Trigwell *et al.* 1994; Roblyer 2002). Available evidence suggests that these two different orientations to the education enterprise result in different learning experiences and learning outcomes for students (Ramsden 1992; Biggs 1999).

There are obvious parallels between these two ‘prototypical’ orientations and some conventional forms of CAL (e.g. knowledge recitation and procedural drill versus simulations and microworlds), but there have been few systematic empirical analyses of these parallels (Laurillard 1993, 2002). Moreover, as a preliminary study in this series indicates (Bain *et al.* 1998b), orientations to teaching with CAL are not likely to be as stereotypic as the reproducing versus constructing contrast outlined above. Bain *et al.* (1998a) analysed the archival records of 36 funded CAL projects and reported seven distinct orientations defined in terms of their positions on five qualitative dimensions of CAL practice. Although the prototypical orientations were clearly evident in the sample, there also were other, more complexly defined, orientations and these were more prevalent. Moreover, there was no clear relationship between orientations and ‘types’ of CAL (such as tutorial systems and databases).

Similar conclusions (about the complexity and diversity of academics’ educational orientations) hold for general teaching and learning beliefs (Fox 1983; Samuelowicz & Bain 1992, 2001; Kember 1997), for educational beliefs within a discipline (Quinlan 1999, 2002), for beliefs about assessment (Samuelowicz & Bain 2002), and for beliefs about the supervision of

research in higher degrees (Murphy *et al.* in press). Accordingly, we anticipated substantial variation and complexity in academics’ orientations to teaching with CAL when using a sample and methods designed to reveal the diversity.

Key research questions

Given the above, the aim of this study was to describe and interpret orientations to CAL practice, where we use ‘orientation’ to refer to a unique pattern of educational beliefs and practices involved in the design and use of a CAL package. Our main research questions were as follows:

1. What belief and practice dimensions are most useful in the description of orientations to CAL practice?
2. What is the range of variation in orientations to CAL practice? That is, what distinctive patterns of CAL beliefs and practices emerge in a broad sample of relevant cases?
3. Do the patterns of beliefs and practices make sense? That is, is each orientation to CAL practice understandable and internally coherent?

Design and procedure

Sample

The cases were 22 CAL projects that had been funded by the Committee for the Advancement of University Teaching (CAUT), an Australian competitive granting agency, during the period 1993–1995. The 22 projects were sampled on the basis of a preliminary analysis of CAL practices (and implied beliefs) contained in their CAUT grant applications and final reports. The analytic framework reported by Bain *et al.* (1998a) was used as the sampling plan. A wide range of disciplines and CAL types was selected. Eighteen of the cases involved a single teacher and four cases involved two teachers who had collaborated closely. The pairs of teachers were interviewed together.

Interviews and other sources of evidence

Participants were interviewed extensively about the design and use of their CAL and about their educational and knowledge beliefs. There were two interviews, each of about 2 h duration. The interviews were

semi-structured, being based on prepared schedules of questions and prompts. Although the schedules set out the nature and order of the matters to be canvassed, the actual order and emphases were determined as each interview progressed. There were two teams of researchers, two per team, and each team handled the data collection for 11 cases.

The first interview focused on the CAL, beginning with a demonstration of its use and then exploring the educational needs that prompted its design and the student capabilities it was intended to foster (such as conceptual knowledge, procedures and skills, methods of inquiry and/or ways of thinking in the discipline). Detailed discussion about the ways in which students work with the CAL also occurred in this interview. Broadly, this interview concentrated upon participants' educational practices, but very often these were discussed and elaborated in connection with their beliefs and values. This interview was video-recorded.

The second interview began with discussion about the ways in which students learn the discipline, and in particular the content and skills associated with the CAL. The nature of the evidence academics had about the learning of their students (e.g. how well students perform in their assessments) was an integral part of the discussion. The broader question of what is good and poor teaching was explored, as was the issue of how the academics' teaching experience (in general and in relation to the CAL project) influenced their beliefs about teaching. This interview usually ended with a discussion about the meaning of scholarship and the possible relationship between teaching and research. Thus, the second interview was focused on educational and epistemological beliefs, but anchored to the educational contexts involved, particularly the CAL. This interview was audio-recorded.

The discussions contained in the recordings of these two semi-structured interviews were fully transcribed. The transcripts were analysed in conjunction with relevant archival material (project reports, journal articles, book chapters), curriculum resources (handouts, texts, exercises, assessments) and student comments and evaluations.

Data preparation

The transcripts and documentary material were collated and condensed into rich descriptions comprising

details of the CAL; the ways in which the CAL was used by students and staff; the educational context in which the CAL was used (content area, other teaching and learning methods in use, learning exercises and assessments, etc.); and the academics' educational beliefs and values. These descriptions were drafted by the interviewing team, and then carefully checked by the members of the other team. In most cases this involved viewing the first interview tape and then reconciling the rich description against the interview transcripts and other sources of evidence.

Data coding and initial dimension selection

Previous belief–practice studies that we have conducted (Samuelowicz & Bain 1992, 2001, 2002; Bain *et al.* 1998a; Murphy *et al.* in press) commenced with a lengthy qualitative classification of the cases, following which the categories thus formed were compared and contrasted to reveal the various bases (dimensions) of qualitative variation. This procedure was not adopted for the present study. Instead the rich descriptions were first coded on belief and practice dimensions, and then categorised according to the similarities among their 'profiles' on those dimensions.

Initially, 18 belief, 16 practice and two scholarship dimensions were used, with some of the practice dimensions being coded in two ways – on the properties of the CAL and on the CAL as used in its course context (called practice-in-context). Most of the dimensions were drawn from published sources (Reeves 1992; Samuelowicz & Bain 1992; Reeves & Reeves 1997; Bain *et al.* 1998a) but some were developed during preliminary examination of the interview transcripts and project documentation. Most dimensions were five-point bipolar rating scales (cf. Reeves 1992), but others involved qualitative differences that could be ordered from teaching-centred to learning-centred. Coding was based on the full weight of evidence available rather than on localised interview comments or archival details.

There were several iterations of refinement of the dimension set to eliminate obvious redundancies and remove dimensions that were not reliably coded (as determined by inter-team differences that could not be resolved). During each iteration, all rich descriptions were re-coded, and the two research teams cross-

checked their codings. At the completion of this very lengthy process (hundreds of hours), the number of dimensions, and the case codes for each, were well stabilised. Table 1 lists the 40 dimensions that were retained for subsequent analyses: 16 belief, 13 practice and 11 practice-in-context dimensions (the last two sets having nine practices in common).

Category formation

The aim of the next stage of the analysis was to reduce the complexity of the data matrix (codes for 22 cases on 40 dimensions) to more manageable and interpretable proportions by grouping similar cases into a smaller number of categories (orientations) and redu-

Table 1. Belief and practice dimensions used for initial coding and after several iterations of refinement.

Dimension ¹	Scale ²
Epistemological beliefs	
Nature of discipline knowledge	Abstract ↔ Situated
Origin of to-be-learned knowledge	Discipline/academic ↔ Student/negotiated
Pedagogical beliefs	
Pedagogical philosophy	Instructivist ↔ Constructivist
Teacher's Role	Didactic ↔ Facilitative
Learning theory	Behavioural ↔ Cognitive
Value of errors	To be avoided or minimised ↔ Opportunities for learning
Intended type of understanding	Knowing more ↔ Knowing differently
Role of discussion in learning	Incidental ↔ Central
Understanding process	●Reproductive/fragmentary ●Reproductive/relational ●Transformational ●Absent ●Pre-emptive ●Conversational
Accommodation of students' conceptions	
Curriculum beliefs	
Learning goal orientation	Sharply focused ↔ Unfocused
Teaching focus	Student development ↔ Academic discipline
Curriculum integration	Sum of the parts ↔ Coherent integration
Curriculum progression	●Linear aggregation ●Jigsaw ●Spiral elaboration ●Minimal ●Social ●Cognitive ●Knowledge & understanding ●Disciplinary/interdisciplinary ways of knowing ●Professional/artistic performing
Role of student collaboration	
Curriculum focus	
CAL practices	
Task orientation	Academic/abstract ↔ Authentic/experiential
Task structure	High (constrained) ↔ Low (open)
Interactivity	Navigational/mathemagenic ↔ Manipulative/constructive
Learning control	Teacher-managed ↔ Student-managed
<i>Collaborative learning</i>	Unsupported ↔ Integrated
<i>Source of motivation</i>	Extrinsic ↔ Intrinsic
<i>Structural flexibility</i>	Fixed time, place ↔ Open access
Learning framework	●Structured ●Guided ●Facilitated
Learning process	Reproduction ↔ Construction
Feedback to students	●Minimal ●Fixed ●Responsive
Place of CAL in the curriculum	Adjunct ↔ Central
CAL contribution to assessment	Adjunct ↔ Central
Learning focus	●Knowledge ●Reasoning ●Performance
General practices	
Focus of assessment	Know more ↔ Know differently
Flexibility of assessment	Fixed ↔ Negotiated

¹Dimensions in bold are those finally adopted after clustering and simplification. Italicised dimensions were coded twice; once rating the CAL practice per se, and again rating the CAL practice as it functioned in the educational context.

²Five-point bipolar scales are indicated by their polar descriptors separated by ↔; qualitative scales are described by bulleted descriptors that are roughly ordered along a teacher-centred to learner-centred dimension.

cing the dimensions to those most useful in distinguishing the categories. To this end, we used the entire belief–practice profile as the basis for category formation. That is, we sought groupings of cases such that the members assigned to a group had similar configurations of beliefs and practices.

Although it may have been possible to group the 22 belief–practice profiles with a qualitative ‘pattern-matching’ procedure, we elected instead to use numerical pattern-matching methods to guide us in category formation. Accordingly, we used numbers to represent the codes on the five-point bipolar (and qualitatively ordered) dimensions, and subjected the resulting matrix to hierarchical clustering analysis (Ward 1963; Jain *et al.* 1999).

Preliminary analyses of the 22 × 40 data matrix revealed five belief–practice clusters that were very stable irrespective of the hierarchical clustering method or distance measure used. To reduce method complexity in subsequent analyses, we adopted Ward’s clustering method with two distance measures: Euclidean distance and Squared Euclidean distance. We next established that the same five clusters (categories) appeared (a) when the five-point rating scales were simplified to three-point scales (to simplify interpretation and presentation); (b) when the 11 practice-in-context dimensions were omitted (although one case changed category, albeit to a ‘nearby’ category); and (c) when additional dimensions were omitted to eliminate non-discriminating dimensions. The five categories reported below are based on the 13 dimensions shown in bold in Table 1. They include two dimensions from each of three broad belief groupings (epistemological, pedagogical and curriculum) plus seven practice dimensions. As a final check on the stability of this solution, we analysed the five-point data for these 13 dimensions and obtained the same five-cluster solution as with the three-point scales.

Having determined the likely categories in the manner just described we then checked each category profile for internal coherence, and for its ability to represent each of the cases assigned to a category. This was a qualitative and time-consuming procedure. Although there were a few instances for which the category profile seemed an insufficient description, we retained the dimensions and categories determined previously because they were a defensible compromise between the complexity of the initial coding and

the simplifications needed to reveal and interpret the dominant patterns in the data. The resulting categories are such that there are small differences in profile within each category, but larger differences between categories.

Findings

Orientations to CAL

The categories resulting from the method described immediately above are briefly described in Table 2, and illustrative cases are provided in Tables 4–8. It is important to note that, although we refer to the *category* patterns in this section, our later emphasis will be upon the individual *cases* whose patterns may differ slightly from their category descriptions.

The main point to note about the categories described in Table 2 is that they represent interpretable yet complex patterns of relationships between beliefs and practices. The two ‘extremes’ – the *thoughtful instructors* and *situated knowledge negotiators* – are recognisable variants of the stereotypes noted earlier, yet they do not fully fit those stereotypes. For example, we refer to the *instructors* as *thoughtful* because, despite their emphasis on instructing students in established discipline knowledge, they have taken careful account of past students’ difficulties and misunderstandings, albeit in a pre-emptive way (i.e. by relying on analogies, animations and other devices to assist understanding and reduce misunderstanding). The *situated knowledge negotiators*, on the other hand, view knowledge as emergent from context, negotiable with the student, and generally not amenable to instruction. In between those extremes are categories in which established discipline knowledge is emphasised (as with the thoughtful instructors), but emphasis is placed on students constructing their understanding with some assistance from the teacher. Table 3 illustrates the ‘fit’ between the classic stereotypes of teacher-centred and learner-centred and our five categories.

Illustrative case profiles

Examples of case profiles for the five categories are summarised in Tables 4–8. For each case, there is a brief description of the technology and the curriculum

Table 2. Descriptions of the five categories of belief/practice patterns.

Categories	No. of cases	Descriptors common to each category
Thoughtful instructors (see Table 4 for example)	3	Strong discipline focus; instructivist/teacher-managed; pre-emptive; highly structured curriculum; extrinsic motivation; minimal or fixed feedback on a reproductive learning process; concerned more with content than process.
Pre-emptive professionals (see Table 5 for example)	6 in two variants, 3 cases each	Strong discipline focus; constructivist/student-managed, but pre-emptive. There may be tensions between constructivist beliefs and implementation (e.g. sharply focused and experiential). Emphasis on case-study methods with experiential focus. Reliance on intrinsic motivation; a mixture of reproductive and constructive learning with some constructive interactivity; guided rather than structured framework.
Conversational constructivists (see Table 6 for example)	5 in two variants, 3 and 2 cases each	Strong discipline focus; strongly constructivist and student-managed; conversational in accommodation of students' conceptions; authentic environments with CAL implementing constructive interactivity; reliance on intrinsic motivation; responsive feedback to students with guidance rather than facilitation.
Learning facilitators (see Table 7 for example)	4	Strong discipline focus; strongly constructivist and student-managed; varied approaches to students' conceptions (non-defining); open task structure (complex problems), but low interactivity (much of work is offline); reliance on intrinsic motivation; little emphasis on collaborative work; facilitated rather than guided framework.
Situated knowledge negotiators (see Table 8 for example)	4 in two variants, 2 cases each	Knowledge is seen as being situated and negotiable with the student; strongly constructivist and student-managed; open task structure (complex problems), but low interactivity (much of work is offline); little collaboration, but it is cognitive in focus; the CAL is facilitative rather than guiding, and provides little feedback; predominantly conversational approach to students' conceptions.

context at the beginning of the table, and notes are provided to illustrate how the codings were assigned.

Although these examples are illustrative of the categories, there is of course variation within each category. Each case has its own nuances that can only be understood by immersion within the case. For several of the cases, we wrote narrative accounts of 2–3000 words. These were reduced for publication (Bain *et al.* 1998b) to less than 1000 words each. However, this limited form is not particularly illuminative. As the focus of this article is the idea that there is a relationship between belief and practice and that this relationship can be interpreted, the narratives have not been included.

What is evident is that, although the relationships between beliefs and practices can be readily interpreted, they are not simply defined. Some beliefs and practices seem to be interconnected in ways anticipated by Reeves (1992) and Bain *et al.* (1998b) (e.g. *beliefs* concerning the origin of knowledge, the type of understanding and the role of discussion, and *practices*

such as learning control, learning process and learning framework), but others are not. Two examples, one of a belief dimension and one of a practice dimension, can illustrate the complexity of the relationship. Table 9 provides the codes for each of the orientations for beliefs about the *accommodation of students' conceptions* and for the practice of embedding *interactivity* in the CAL being used.

It is interesting to note that in none of our cases does a teacher adopt the view that students are 'empty vessels' waiting to be filled with knowledge. All of the teachers in this research study acknowledged that students came to their classes with prior knowledge and conceptions. Typically, students' conceptions can be taken into account in one of two ways: one pre-emptive, the other collaborative. A pre-emptive approach draws upon past students' difficulties to 'transform' discipline concepts into forms (such as analogies, metaphors and computer animations) that are more likely to be correctly understood (Shulman 1987). The assumption of this approach is that

Table 3. Frequencies of belief codes for each of the orientation categories (using three-point belief dimensions that are roughly ordered from teacher-centred to learner-centred).

Orientation category	Teacher-centred		Learner-centred
Thoughtful instructors	9	4	0
Pre-emptive professionals	2	8	3
Conversational constructivists	1	2	10
Learning facilitators	5	1	7
Situated knowledge negotiators	2	0	11

knowledge presented in a ‘student-friendly’ way will prevent or replace students’ naive conceptions. Evidence suggests that this assumption is incomplete, at best (Stones 1992). A conversational (Pask 1976; Laurillard 1993, 2002) or collaborative (Totten *et al.* 1991; Roschelle 1992) approach, on the other hand, assumes that understanding has to be negotiated through discussion that gradually converges on more appropriate interpretations than those initially held by the students. In our cases, there is a clear divide between academics who believe that students’ perspectives should be dealt with pre-emptively and those who assume that a more conversational approach is needed (Table 9).

However, this alignment with the orientations is not as straightforward when we examine the codes for interactivity. In the writing about CAL design, there is often an implicit assumption that the CAL has to be ‘highly interactive’ if students are to achieve personal knowledge construction. Our study complicates this presumption. The interactivity dimension in our study incorporates the ‘user activity’ (mathemagenic ↔ generative) dimension postulated by Reeves (1992). In accord with Hannafin (1989), Reeves used the term ‘mathemagenic’ to refer to activities that access pre-formed representations of content, whereas ‘generative’ activities involve the learner in the creation or manipulation of representations. On the face of it, mathemagenic interaction should typify instructivist orientations, and generative interaction should characterise constructivist orientations. However, this simple partition did not occur in our sample. For example, most of the learning facilitators and situated knowledge negotiators adopted mathemagenic interactions, despite their strong beliefs about the importance of student-constructed understanding.

They were not inconsistent, however. Rather, they embedded the (often mathemagenic) CAL within constructivist/conversational activities undertaken offline. This is an excellent illustration of the observation that the CAL is only part of the teaching and learning context of a university course (Laurillard 1993; Wills & McNaught 1996). It also confirms that the links between beliefs and practices can be complex, yet understandable when the entire teaching–learning context is taken into account.

Internal coherence

To illustrate our claim that each category is internally coherent, we will consider the coding for *learning facilitators* (one of the two orientations referred to immediately above). Were we just to consider the overall balance between teaching-centred and learning-centred codes (Table 3), we could be left with the impression that this category is incoherent (bipolar) in its beliefs and practices, because five of the codes are more teacher-centred in character and seven are more learner-centred. However, as noted above, this way of interpreting the orientation is overly simplistic. Teachers in this category are quite consistent in their behaviour in that, while they are highly focused on establishing discipline knowledge, they also believe that this knowledge cannot be acquired by a simple instructivist approach. A key feature of this category is the use of a clear discipline framework that provides clarity on the knowledge outcomes students are expected to reach. Further, the emphasis is on each student’s individual journey of learning and less on collaborative activity. However, within this discipline-bounded framework, students have a great deal of freedom to explore knowledge, and construct and validate personal understanding. Learning facilitators, thus, show strong alignment with the tenets of their disciplines while supporting students through open-ended tasks and providing access to resources for students to grow in their own understanding.

Discipline stereotypes?

There is often an assumption that academics in the sciences are more likely to have a strong discipline focus – and corresponding instructivist orientation – compared with academics in the arts fields. Our data

Table 4. Case description and profile of two thoughtful instructors of first-year chemistry.

Dimensions	Category code	Case profile	Comment
Beliefs			
Nature of discipline knowledge	Abstract	● ○ ○	Frank and John ¹ are focused on the basic principles of chemistry. They see these as central to working in chemistry.
Origin of to-be-learned knowledge	Discipline/academic	● ○ ○	In the first year, learning chemistry is seen as working through an orderly array of basic knowledge and skills.
Pedagogical philosophy	Instructivist	● ○ ○	Because the basic structure of chemistry is known, the main aim for students is that they acquire this set body of knowledge.
Accommodation of students' conceptions	Pre-emptive	○ ● ○	Frank and John believe that most basic misconceptions in first year chemistry are known; their role is to provide good explanations, demonstrations and animations to clarify areas of difficulty.
Learning goal orientation	Sharply focused	● ○ ○	The carefully designed modules are intentionally matched to learning goals
Role of student collaboration	Minimal	● ○ ○	Student discussion is seen as valuable, but incidental, and so there are no planned activities to encourage this.
Practices			
Task orientation	Academic/abstract	● ○ ○	There is an emphasis on the basic language and processes of chemistry.
Task structure	High	● ○ ○	Within each module the sequence of tasks is fixed and each task is explicitly defined.
Interactivity	Navigational/mathemagenic ²	○ ● ○	Students do not construct models on screen but they can view animations and movies several times. There is also a range of strategies for answering questions.
Learning framework	Structured ²	○ ● ○	Tasks are designed so that students can get hints, rather than full explanations. Other cases in this group were more structured.
Learning control	Teacher-managed	● ○ ○	The sequence and nature of the exercise cards are determined for students.
Learning process	Reproduction	● ○ ○	Emphasis is placed on learning the well-established theories and processes in basic chemistry.
Feedback to students	Fixed	○ ● ○	Although there is quite detailed feedback available, it is fixed.

¹Pseudonyms.²The case code differs from the category code on this dimension.

The CAL is embedded in a terminating first-year chemistry course that attracts a large and diverse student group. The content of the CAL is typical of a first-year course in university chemistry. The CAL modules were developed using a modified HyperCard™ application (subsequently translated into a Web-based format with technical refinements but with essentially the same educational design). The CAL modules have replaced two lectures each week and are thus a primary learning strategy for students. Each module consists of a sequence of information cards, supported by video, animations or graphics, followed by a series of questions pertaining to the information base. The cards in each module follow each other sequentially and students progress through a given module following this sequence. Each module takes between 60 and 70 min to complete. The exercise cards utilise a number of different question formats such as checkbox (true/false and multiple-choice); numerical calculations; symbolic entry for formulae and structures; text placement for labelling diagrams and sentence completion; and rank order items.

Table 5. Case description and profile of a teacher of commercial law classified as a pre-emptive professional.

Dimensions	Category code	Case profile	Comment
Beliefs			
Nature of discipline knowledge	Abstract ²	○ ● ○	Business law is an applied discipline. Anne ¹ is both strongly influenced by legal principles and also by how these principles might be interpreted in business contexts.
Origin of to-be-learned knowledge	Discipline/academic ²	○ ● ○	Anne believes that the principles and statutes of law are a clearly defined body of knowledge (what she calls the vocabulary). However, the emphasis of a students' field also needs to be considered.
Pedagogical philosophy	Instructivist/hybrid ²	○ ● ○	A belief in cognitive apprenticeship has guided the design. Students are provided with highly structured algorithms for the application of law, but eventually they have to carry out their own application and reasoning.
Accommodation of students' conceptions	Pre-emptive	○ ● ○	Anne sees her years of teaching experience, and those of her colleagues, as being a strong asset in designing materials and activities (especially questions to be answered) so as to allow students to address most common misconceptions.
Learning goal orientation	Sharply focused	● ○ ○	Although Anne recognises that students need to engage on a personal level to learn effectively, she has a clearly defined set of knowledge and cognitive skills that she feels are needed for students to use the law in business contexts.
Role of student collaboration	Mixed	○ ○ ●	In both the on-campus and distance courses, tutorial discussions are seen as being important for student learning. The emphasis is on specific feedback at the level of fine detail to questions rather than the development of social skills. The overall group code is mixed.
Practices			
Task orientation	Authentic/experiential	○ ○ ●	Two examples illustrate this. 1) The video provides a realistically messy case in which application of the law is 'grey'. 2) The conceptual maps show linkages between the various areas; the material of each topic needs to be understood in relationship with other topics, and then applied to actual scenarios.
Task structure	Low ²	○ ● ○	Students are given the freedom to use the CD-Rom in any way they find necessary and can explore it at any depth.
Interactivity	Manipulative/constructive ²	● ○ ○	Unlike other members of this sub-group, navigation is primarily for the purpose of locating and being led through material rather than for user construction of understanding.
Learning framework	Guided	○ ● ○	Students have a clearly laid out learning map and also have carefully structured support and guidance about how to proceed in using this framework. While students can work in different ways, there is an expectation that in the end, they will adopt the framework and procedures offered.
Learning control	Student-managed	○ ○ ●	The CD-Rom is designed to allow students freedom in how they choose to progress through the material.
Learning process	Hybrid (typically a mixture of beliefs)	○ ● ○	There are heuristics to assist with problem solving, e.g. a set of questions to assist analysis, a series of steps to use and indications about the level of detail needed. The 'hybrid' code is used for this group because there is an emphasis on a pre-defined solution pathway for problems, even though the solutions are not predetermined.
Feedback to students	Fixed	○ ● ○	On the CD-Rom, feedback is given for every answer, whether right or wrong but it is fixed.

¹Pseudonym.²The case code differs from the category code on this dimension.

The context is commercial law relevant to business areas such as accounting, banking, finance and local government – law for non-lawyers. The course is designed for use by both undergraduate on-campus and distance students. The CAL materials are on a CD-Rom. The design of the CAL is centred on hierarchical concept trees. There is always an icon present to indicate which of the three levels is currently being accessed. One can move easily between levels. A series of icons (representing an index, a glossary, cases, statutes, questions, strategies, video, a note-pad, a print function and a navigation button) enable students to explore topics in a variety of ways. There is a case video that is not linked directly to any one section but is designed to show how many aspects interrelate. The large bank of questions with feedback assists students in developing skills in analysing situations, finding appropriate legal information and suggesting suitable procedures to follow. Students have an additional resource through the strategies button that provides them with a range of appropriate legal procedures to consider and apply to the problems. The CAL is an optional learning support tool and is referred to in lectures, tutorials and in the printed materials. It is thus not central to the course but is well-integrated with other activities.

Table 6. Case description and profile of a language teacher classified as a conversational constructivist.

Dimensions	Category code	Case profile	Comment
Beliefs			
Nature of discipline knowledge	Situated	○ ○ ●	For Jean ¹ , language is inextricably bound up with culture. Language learning is not defined by a set of linguistic rules or a list of vocabulary; these rules and words are necessary, but successful language learning involves understanding culture and nuance.
Origin of to-be-learned knowledge	Discipline/academic	● ○ ○	While language learning must be situated in the complex and changing context of the target culture, Jean does believe that language is something that students can negotiate or change.
Pedagogical philosophy	Constructivist	○ ○ ●	Jean believes that language cannot be learnt in the abstract. Students need to progressively construct understanding through testing out their language skills in interactive situations. Jean refers to this as 'negotiation of meaning'.
Accommodation of students' conceptions	Conversational	○ ○ ●	Jean does not explicitly refer to students' misconceptions, although errors and misunderstandings are implied. She speaks instead of a constant refinement of language capability through repeated communication during which ways of using the language are tried, assessed and then reframed.
Learning goal orientation	(no dominant belief)	○ ○ ●	For Jean, language learning is a process of individual development in communicative competence, not a tightly defined learning process. Other cases in this group are in the sciences and have a more sharply focused learning goal orientation. It is likely that the nature of the discipline is a significant factor here.
Role of student collaboration	Cognitive	○ ○ ●	Jean believes that students can assist each other very effectively in learning. They can understand each other's difficulties and provide feedback at appropriate levels.
Practices			
Task orientation	Authentic/experiential	○ ○ ●	Students work with video clips, sound tracks and stories that have been designed to be authentic in language and imagery, and thus students have a degree of immersion within a natural language context.
Task structure	Low ²	○ ● ○	Depending on the media elements chosen, the teacher can focus the attention of the students on a particular theme, cultural situation or communicative function. Individual tasks are structured but there is a variety of structure.
Interactivity	Manipulative/constructive	● ○ ○	One illustrative example: Students communicate via the computer with each other to complete a text or graphic. One of the students has the text or graphic; the other student has to ask questions that will enable the first student to complete the text (such as a short story) or graphic (such as a face).
Learning framework	Guided	○ ● ○	Jean has designed the CAL so that students work from their existing base of language competence. The course is designed so that students receive feedback from the CAL, from the teacher and from other students. Other members of this sub-group were more facilitative.
Learning control	Student-managed	○ ○ ●	Within the overall parameters of the tasks that Jean has designed, students have freedom to decide how to work in ways that suit them.
Learning process	Construction	○ ○ ●	In developing language competence, there are no absolute rules for aspects such as nuance and style. Each student needs to construct her or his own approach.
Feedback to students	(no dominant belief)	○ ○ ●	In several activities, students give feedback to each other in a highly responsive way.

¹Pseudonym.²The case code differs from the category code on this dimension.

The context is undergraduate language learning of both European and Asian languages. The project has developed language-learning shells designed to complement communicative language courses and provide teachers with specific computer-based templates for language learning and teaching. Language shells were considered preferable to the development of a set of one-off lessons so as to have flexibility in producing materials linked to specific courses – both in terms of choice of language and in curriculum design. The shells can incorporate text, audio, graphics and video in the development of 'authentic' scenarios designed for learners to comprehend and engage with language events. There are collaborative activities for the classroom, and also tasks for individual student use. Tracking capability has been built in to assist evaluation.

Table 7. Case description and profile of a science teacher educator classified as a learning facilitator.

Dimensions	Category code	Case profile	Comment
Beliefs			
Nature of discipline knowledge	Abstract	● ○ ○	The focus is on the logic of science rather than the particular context of any problem. Michael ¹ believes that scientific ideas can be a general tool for developing understanding.
Origin of to-be-learned knowledge	Discipline/academic	● ○ ○	The knowledge that Michael is concerned with centres on the rules of scientific process, of prediction and testability, and then on how these scientific ideas have leverage in a range of contexts. These rules are well accepted in the scientific community.
Pedagogical philosophy	Constructivist	○ ○ ●	Michael believes that true scientific understanding is built as learners conjecture and test their interpretations of phenomena in the world. He sees this as totally contrary to instructivist philosophies underpinning much primary and secondary science teaching.
Accommodation of students' conceptions	Conversational	○ ○ ●	Michael uses the term 're-learning' when discussing the process of how students work with their existing conceptions. If the prediction and experimental result do not agree, there is an opportunity for re-learning.
Learning goal orientation	Unfocused	○ ○ ●	Michael is interested in shifting the teaching of physics from an algorithmic approach to one of seeing it heuristically. In doing so, he cannot pre-specify the path that any individual student will take.
Role of student collaboration	Minimal	● ○ ○	Michael believes that learning (or re-learning) occurs when students see their existing ideas as being inadequate. This is a personal confrontation. The outcome of learning is seen as growth and change in individuals.
Practices			
Task orientation	Academic/abstract	● ○ ○	Although everyday objects (like a toaster) are used, the emphasis is on understanding the ideas of conservation of charge in a circuit, rather than on working with practical applications of physics.
Task structure	Low	○ ○ ●	Re-learning is a slow, personal, rigorous journey centred on tasks with minimal structure. There can be no 'one size fits all' approaches to designing learning environments for students.
Interactivity	Navigational/mathemagenic	● ○ ○	Although Michael provides kits with which learners can construct electrical circuits (suggesting a constructive form of interactivity), his emphasis with the CAL is upon viewing animated analogies for circuits. This indicates a predominantly mathemagenic form of CAL interactivity.
Learning framework	Facilitated	○ ○ ●	The design of the learning tasks is to enable students to confront and redevelop their ideas. Michael relies on the use of analogies to provide opportunities for students to see problems in a new light. Analogies are concrete representations that can assist students in building personal mental models of the conservation of charge.
Learning control	Student-managed	○ ○ ●	Michael sees students' questions as the initiators of learning sequences. Without this trigger, learning cannot occur. So, while the teacher designs the CAL and other learning materials, provides activities and sets the scene, students need to interact with and interrogate the environment.
Learning process	Construction	○ ○ ●	The teacher needs to provide enough opportunities for students to build up their own ideas on the conservation of charge, without telling them the accepted answer. The analogies are there as a support, a scaffold, in this process of construction.
Feedback to students	Fixed	○ ● ○	Only the ammeter readings are available. Michael does not see the computer as being useful for providing detailed and tailored feedback.

¹Pseudonym.

The design of the materials in this case is based on the concepts of generative teaching. A process of analogical reasoning is used in which students predict electrical circuit phenomena, and then test their predictions by accessing animated analogies (CAL) for the conservation of electrical charge in circuits. Students may go through several phases, slowly increasing in accuracy and confidence. A CD-Rom, an electrical kit and a reader are designed to be used together. The materials have been used with students in teacher education courses so that primary and secondary teachers can gain confidence in their own construction of scientific thinking.

Table 8. Case description and profile of two mathematics teacher educators classified as situated knowledge negotiators.

Dimensions	Category code	Case profile	Comment
Beliefs			
Nature of discipline knowledge	Situated	o o •	Mary and Neil ¹ are quite clear in their belief that knowledge in the discipline of education is situated. They speak naturally and articulately about situated cognition.
Origin of to-be-learned knowledge	Student/negotiated	o o •	Mary and Neil see education as an unusual discipline in that there are many component sub-disciplines – psychology, sociology, philosophy, history, design, etc. The whole (the discipline area of education) is more than the sum of the parts. Each teacher foregrounds and backgrounds the component sub-disciplines depending on a whole range of prior and current experiences.
Pedagogical philosophy	Constructivist	o o •	Each teacher education student needs to develop a unique suite of approaches and resources. Mary and Neil see this occurring best when students can access a rich resource set in order to construct meaning.
Accommodation of students' conceptions	Conversational	o o •	Mary and Neil believe that students will develop understanding by being immersed in practical teaching experiences, after which they are encouraged to discuss with other students their developing conceptions and the issues they experience.
Learning goal orientation	Unfocused	o o •	For Mary and Neil, it is important that teachers can identify what key issues face them. This set of issues or problems will be different for each teacher.
Role of student collaboration	Cognitive	o o •	Mary and Neil quite clearly believe that students will learn more when they discuss their ideas with their peers.
Practices			
Task orientation	Authentic/experiential	o o •	The simulated world of the CD-Rom offers an experience that is much more authentic than text alone. It is also designed to cover more options than students are likely to get in real school settings. For Mary and Neil the combination of the rich resources, together with experiences in schools, provides the best arrangement.
Task structure	Low	o o •	Students may select an investigation from the options provided in the booklets that accompany the modules, or undertake a task of their own choice.
Interactivity	Navigational/mathemagenic	• o o	There are a large number of resources (over 60 video clips and over 80 documents) to access, but these are to be read or viewed. There is a notebook but that is basically just for word processing.
Learning framework	Facilitated	o o •	Students are able to explore the information base with a reasonable degree of flexibility in classroom times and in their individual and collaborative research. The 'facilitator' in the classes negotiates the assignment tasks and moves around assisting students in using the program.
Learning control	Student-managed	o o •	Interface design encourages student control. The metaphor used is that of a classroom with filing cabinet (where all the resources are), whiteboard (where the menu is), television (where all the media loads), and table (where the notebooks are). All resources can be accessed independently. There is also flexible access in terms of time.
Learning process	Construction	o o •	Both the student and the teacher contribute to the learning process. Students need to determine which material is important for them to understand if they are to become mathematics teachers; they are encouraged to develop their own perspectives on the issues. It is the role of the teacher to coach and scaffold student learning.
Feedback to students	Minimal	• o o	The CD-Rom is intended as an information resource. There are no feedback elements at all. Feedback comes through discussions with peers and with the lecturers.

¹Pseudonyms.

This comprehensive mathematics education package on assessment is designed for both on-campus and distance students. It contains a CD-Rom on assessment in mathematics education incorporating video clips of teachers using various assessment techniques within their classrooms, with original sound; video clips of teachers reflecting and discussing the strengths and weaknesses of the approach; video clips of children discussing their feelings and thoughts; interviews with experts in the field providing theoretical perspectives; text description of each assessment category; teacher and student work samples; and a problem-based notebook providing a variety of tasks within which to examine the resource. All this is accessible in areas of an online classroom. There is also an instruction book for facilitators and a set of blackline masters of the authentic activities (also provided on the CD-Rom) to enable students to have the task in front of them at all times if required.

Table 9. Orientation codes for two selected dimensions.

Two selected dimensions	Orientations to CAL				
	Thoughtful instructors	Pre-emptive professionals	Conversational constructivists	Learning facilitators	Situated knowledge negotiators
Accommodation of students' conceptions of interactivity	Pre-emptive Navigational/mathemagenic	Pre-emptive Manipulative/constructive	Conversational Manipulative/constructive	Conversational Navigational/mathemagenic	Conversational Navigational/mathemagenic

do not support this contention. For example, although the case outlined in Table 4 fits the 'science-as-instructivist' stereotype somewhat, another science-based case (Table 7) was placed in the learning facilitator category along with cases from history and fashion. Similar discipline heterogeneity occurred in the other categories. The placement of a case in any one category was determined by the relationship between beliefs and practices, and all cases were internally coherent as we have illustrated by the comments in the right-hand columns of Tables 4–8.

Conclusions and implications

So what are some of the main points of significance that we think can be gleaned from this detailed set of case descriptions and the five belief–practice orientations we have derived from the data? We commenced with a set of research questions that centred on coding and interpreting the relationships between academics' educational beliefs and practices. The answers to these research questions are framed in the five belief–practice clusters. These clusters illustrate that dichotomous descriptions appear to be insufficient if we want to understand how teachers interpret the possibilities of using technology in their teaching and then make decisions about how they might actually use technology. The resistance to the adoption of technology in university teaching could well be because of the fact that teachers do not identify with the classic teacher-centred/student-centred descriptions given by academic staff developers. Teachers are aware implicitly, if not explicitly, that their own motives and curriculum decisions are complex and so we are not doing teachers a service by simplistic definitions and descriptions.

The research undertaken in this study was immensely time-consuming but we believe that additional work is needed, particularly to take into account Web-based and mobile technologies, many of which post-date the present sample. For example, it will be important to learn whether academics can practice effectively within the constraints of current learning management systems. It will also be important to establish whether the belief and practice dimensions that were optimal for our sample will be as useful in other contexts.

Finally, we believe that more research-led academic staff development is needed in the CAL area. One approach worth further investigation would involve

academic teachers coding their own beliefs and practices in sessions facilitated by staff developers, and then deciding how they might incorporate technology into their framework so as to enhance student learning. This approach presupposes that all of the orientations we have documented (and others yet to be revealed) can give rise to sound learning, provided the academic teachers strive for internal coherence between their educational beliefs and practices, and deploy technology in a way that augments their existing methods.

It is our expectation that the present work will contribute to a better understanding of the complexity of the relationships between teacher beliefs and practice in the use of technology in higher education, and that this will, in turn, result in a greater and more meaningful uptake of technology in our universities.

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