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Concept mapping to support university academics' analysis of course content

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The authors' goal in working with university academics is to support an intellectual process of close examination of instructional decisions, making explicit the rationale and intentionality underlying those decisions. Subject matter understanding is the primary point of reference in this process. The focus of the research described here is the use of an unstructured form of concept mapping to support academics in the analysis of course content as the first step in a course design process. While some academics with whom the authors have worked have been initially skeptical about concept mapping, the large majority of them, in the end, report that they value the process and what they gained from it. The findings show that the concept mapping process provided an alternate means to rethink course content, one that highlighted relationships among concepts, encouraged a view of the course as an integrated whole, and frequently provided the occasion to make explicit the types of thinking required in the course.

Our work is premised on the notion that academics develop into accomplished instructional decision makers through an intellectual process in which their subject matter understanding is the primary point of reference. This view has led us to adopt an orientation to teaching development that is at once both intellectual and practical, in that we engage academics who work with us to make explicit their decisions about teaching and the rationale underlying those decisions. Essential to this strategy is the process of reflection, which we see as the mechanism that fosters the development of knowledge and understanding of teaching (McAlpine and Weston 2000).

The focus of the research described here is the use of concept mapping to support academics in the analysis of course content, as the first step in a course design process. Thus, academics begin the course design process by producing an explicit representation of their course content as they personally understand it, and use this representation to develop statements about student learning that, taken together, provide the academic (and potentially the student) with a clear understanding of knowledge development within a specific course. Reflection is designed into this process, provoked by self and peer critique. For the last ten or so years, we have collected anecdotal evidence of the value to academics of concept mapping as a reflective, analytic tool (Amundsen, Gryspeerdt, and Moxness 1993; Amundsen, Saroyan, and Donald 2004). In this article, we formally investigate these anecdotal claims by addressing two questions:

- How do university academics explain the changes they make to successive concept mapping drafts, and the implications of these changes for the course they are designing?

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- How do university academics describe the process they engaged in to develop the concept map, and in particular how they incorporated peer feedback?

Context and background

The concept mapping process we discuss in this article is part of a five-day course design workshop, now offered at several universities in Canada (for detailed information about this workshop, see Saroyan and Amundsen 2004). In the 1990s, when this workshop was first developed, the most common format of faculty development in North America was the short topical workshop with a focus on generic teaching skills (as reported in three reviews of the literature: Emerson and Mosteller 2000; Levinson-Rose and Menges 1981; Weimer and Lenz 1991). These workshops were most often focused on specific teaching skills (e.g. presentation/lecture skills, how to develop a course outline, how to construct an examination). Generally, these skills were taught in isolation without any attempt to connect them with an academic's existing understanding of pedagogy or, perhaps more importantly, their understanding of knowledge development in their discipline (Neumann 2001). Shulman (1993) suggested over 10 years ago that many academics feel profoundly isolated when it comes to teaching and rarely, if ever, have meaningful discussions about teaching with their academic colleagues. Shulman argued that one of the reasons for this situation was that teaching is often viewed as simply a matter of generic skills (e.g. becoming a better presenter, knowing how to facilitate discussion), and disconnected from disciplinary understandings of knowledge development.

Our review of the literature and our experiences as academics and faculty developers prompted us, as we created the initial design of the course development workshop over a decade ago, to design a workshop that was different, in several ways, from the common format of the day. The subject matter understanding of participating academics was placed front and center in the workshop design, providing a lens with which to view all aspects of the course design process. This single notion has become the most powerful impetus in the evolution of our thinking about how to most effectively work with our academic colleagues in the pursuit of teaching development.

Subject expertise, for most academics, is a source of passion and confidence, their primary allegiance (Becher and Trowler 2001; Jenkins 1996). It is commonly their research expertise, not their teaching expertise, which leads to their success in the academic world (McMahon 2001). Yet, they still spend a great deal of time teaching courses and supervising students, although it is likely they have not been socialized to think about their discipline in terms of learning or teaching tasks (Riordan and Roth 2005). It is not surprising that academics often describe their own experiences as learners as the main influence on their teaching (Willcoxson 1998). Such experiences are unlikely to have included the distinctness of knowledge-making practices as an explicit part of the curriculum, since disciplinary norms and practices often remain tacit (Lenze 1995; Polanyi 1966). Articulating this invisible curriculum requires metacognition, dissecting one's own largely unexamined thinking (Bransford, Brown, and Cocking 2000). Further, since most academics chose their fields because they were successful at the kind of thinking required, they may have leapt almost without effort over the bottlenecks to learning or 'threshold concepts' (Meyer and Land 2005) that can prove daunting for many college and university students (Pace and Middendorf 2004).

A common approach to course design used by faculty developers is drawn from the literature on instructional design, usually involving a sequential process that begins with the development of learning objectives or outcomes, and proceeds from there to consider teaching, learning and assessment strategies (e.g. Dick and Carey 2001; Smith and Ragan

2005). At the time of the initial development of the workshop, we too often employed this approach. We recognized that this approach was not the only way to design instruction, but we used it because it was relatively straightforward and the basic principles could, more or less, be adapted to fit various disciplines. We came to realize that the starting point, the development of learning outcomes, was problematic (as well as other aspects not discussed here), because it assumes that instructors have a clear, explicit, coherent and personally congruent understanding of the content of the course they are designing.

We considered the ways that we had experienced academics going about determining the content of their courses. A few engaged in some sort of analysis of the content with some form of visual representation, but not necessarily. Most relied on the course outlines of previous offerings of the course, or used the content and structure of a current textbook. In either case, the end product was usually a list of lecture topics assigned to specific class dates. This we saw as problematic for several reasons. A list of topics tends to, though not always, lead both instructor and students to think of the content as a series of discreet 'chunks' of an unspecified whole. The process of creating the list may not involve much thinking about the importance of each topic relative to the other topics, or about the nature of the relationships between topics. Furthermore, lists of topics based on previous offerings of a course, or taken from a textbook, may not be consistent with an academic's personal understanding of that content. Many academics have told us that they feel tension because the way the content of a course is structured, and the way they are trying to teach it, is sometimes different from their own understanding of the content (Clark and James 2004). It was clear to us, for these reasons, that we needed a different process for determining the course content.

The first author was well acquainted with the work of Novak and Gowin (1984), who developed the notion of concept maps as a strategy to develop and evaluate the conceptual knowledge development of primary and secondary school students in science education. Concept mapping was based on the assimilation theory of learning, one of the first theories to take a cognitive view of learning (Ausubel, Novak, and Hanesian 1986). It posits that individuals learn by organizing, relating and integrating new concepts into their existing cognitive structures. Concept maps, used for this purpose, have been described as valuable because they 'provide the opportunity for individuals to reveal their understanding of conceptual relationships and to adjust and readjust the map as understanding changes' (Kinchin, Hay, and Adams 2000, 44). For a comprehensive review of the research on school age and post-secondary students' construction of concept maps, or use of already created concept maps, for learning purposes, see Nesbit and Adesope (2006).

Research investigating the use of concept mapping to evaluate students' knowledge in science or science-related fields in higher education (for example, medical education) most commonly represents concepts maps as hierarchical and sequential, with more inclusive concepts at the top of the map and more specific, less inclusive concepts placed below. The resulting image looks somewhat like an upside-down tree. If one thinks of this from the perspective of how knowledge is structured in different disciplines, then we might explain this based on the argument that knowledge in the hard sciences is highly structured (Kuhn 1970), and that students must master basic concepts before moving on to other related concepts, a sort of 'building block' notion. Donald (1983) applied concept mapping, or what she termed 'knowledge structures', more broadly to investigate how academics viewed 'the structure of knowledge in courses in various disciplines in the university … to uncover different structures and to make comparisons among them.' (31). Among the findings of this research, Donald reports that 'in the physics course the tree structure was hierarchical with branches from more to less important concepts. Among the humanities courses, a linear formation or loose block was most frequently found. The most common form in the social

science courses was a web or cluster of concepts linked to a pivot concept such as "socialization"' (36–37). Relevant for us was Donald's remark that, even though the primary purpose of her study was not to develop the thinking of the academics who were participants in her study, many of them told her that the activity of identifying the most salient concepts in their courses, and identifying the closest or most dominant relationships among these, was one of the most useful clarification techniques of course content that they had been involved in. The same sentiment has been echoed by many of the academics with whom we have worked. Indeed, there are several reports of using concept mapping with pre-service secondary school teachers to identify gaps and misconceptions in subject matter understanding, especially in the sciences (for example, Lang and Olson 2000; Machin, Varleys, and Loxley 2004). Pre-service secondary school teachers, the focus of these studies, might be considered as relative novices in terms of their disciplinary knowledge, as compared to the subject matter experts, the academics with whom we work. Nevertheless, this work highlights the potential of concept mapping as a tool for making subject matter understanding explicit, and as a prompt for self-reflection.

It could be argued that one of the reasons why concept mapping is effective, as a way to explicate subject matter understanding, is because the basic structure of major concepts and the visual depiction of the relationships among them constitute two of the ways a discipline can be understood. Disciplinary cultures vary greatly in their knowledge-making practices (Becher 1994; Becher and Trowler 2001), in their discursive practices, research methodologies and theoretical reasoning, or what Schwab (1962) calls their conceptual and syntactical structures. Donald (2002), drawing on the work of Hirst (1974), suggests a framework for understanding disciplinary differences based on four ways of conceptualizing knowledge and inquiry in a discipline, each building on the previous level. The first is through concepts defined as a 'a unit of thought, an element of knowledge that enables us to organize experience … any given concept exists within a larger framework which may take the form of a structure, process, or larger category' (Donald 1983, 32). It has been argued that 'to understand a concept entails having an internal representation or mental model that reflects the structure of that concept' (Halford 1993, 7). The next level of the framework addresses logical structures defined as an 'organization of concepts showing the relationships between component parts; a schema' (Donald 2002, 9). A concept map, by virtue of its basic elements of construction, makes these two ways of conceptualizing knowledge explicit. A third level of the framework for understanding disciplinary differences is the criteria and processes used to determine validity, and defined as 'standards by which we validate knowledge' (9). The last level involves the methods and modes of inquiry, defined as 'the processes of thinking and operations used to describe them.' (9). In our experience, only some of the concept maps created by the academics we have worked with include these last two ways of conceptualizing knowledge. Nevertheless, concept maps are a tool that has the potential to lead academics through all levels of this framework and this, in our view, provides a strong rationale for using them as a first step to course design specifically, and to reasoned instructional decision making more generally.

How we use concept maps

Several approaches to the development of concept maps are described in the literature. In designing our approach, which has evolved over the years since the initial design of the workshop, we have kept three main purposes in mind. First, an instructor's personal understanding of the course content should serve as a lens through which all other course design elements are considered. Secondly, the explicit and personal representation of course

content should be clearly and explicitly linked to statements about goals for student learning in that course. Third, the process of concept mapping should prompt the instructor to examine unclear or taken-for-granted assumptions about the structure of knowledge in the course. Further, it is our long-term purpose that concept mapping will prompt academics to consider how students learn, and how to move students towards thinking in a disciplinary manner. To address these purposes, we have arrived at an iterative process of developing and reflecting on multiple drafts of the concept map through both self and peer critique. This process is detailed in the appendix. In this article, we formally investigate two questions: how university academics explain the changes they make to successive concept mapping drafts, and the implications of these changes for the course they are designing, and how university academics describe the process they engaged in to develop the concept map, and in particular how they incorporated peer feedback. These questions constitute a beginning in the formal investigation of whether we are achieving our purposes in using concept mapping.

Mode of inquiry

The majority of published studies that assess changes in concept maps over time do so to track the development of knowledge in the novice learner. Scoring protocols (for example, Novak and Gowin 1984) have been used to document increased complexity (i.e. numbers of concepts, subconcepts and crosslinks). In this case, increasing complexity is assumed to be an indicator of increasing expertise about a specific area of study. In a more recent treatment, concept maps of novice learners were subjected to an analysis to uncover shapes akin to spokes, chains or nets, with the idea that each of these shapes relates to a particular level of understanding (Kinchin 2001; Kinchin, Hay, and Adams 2000). Often the maps of novices are compared to those of experts, with the assumption that there is a more correct or expert standard to work toward.

We do not work with novices, but rather subject matter experts who have a sophisticated understanding of the subject matter to draw upon. The primary goal of the concept mapping activity in our workshop is increased clarity for the academic, and the personally meaningful organization of critical course concepts to support learning. Unlike many studies, we are not looking for increasing complexity or simplicity in successive concept mapping drafts, although the latter is more common in our experience with academics. Therefore, scoring protocols that tally the numbers of concepts, subconcepts and crosslinks are not appropriate for our purposes. More appropriate for our purposes is an analysis of concept maps that is grounded in the map creator's own explanation of thinking and changes in thinking, rather than in the interpretations of the researcher. In this way the role of the map's creator is expanded into one of analysis. This approach is different from others we have read about in several ways, but perhaps most significantly because we focus on the thinking underlying the map rather than an analysis of only the product, the map itself.

Participants and data collection

Over a three-year period (2003–2005), we reviewed the successive concept mapping drafts of 48 academics, who comprised a subset of those who had participated in multiple offerings of the five-day course design workshop at two different universities. During the workshops, we asked all participants to keep and number the concept map drafts they produced. We interviewed, in the end, a total of 11 academics, selected to represent a variety of disciplines. Interviews were conducted, in each case, within a few weeks of completion of the workshop. Thus, the data sources analyzed in this study are concept maps and interview transcripts.

All 11 academics are tenure track faculty (i.e. involved in both teaching and research); only one was tenured at the time of data collection. They represent the following disciplines: business and management, computing science, education and educational psychology, engineering, library sciences, medicine, physics and social work. All but two had taught the course they worked on during the workshop at least once before.

Each interview was conducted by one of the authors. The interviews ranged from 45 minutes to just over an hour. All interviews followed the same interview protocol. The interviewees were asked to spread out the concept map drafts, so that they were in clear view for themselves and for the interviewer. The primary question asked was: 'I am very interested in understanding your thinking and how it may have changed from draft to draft. Would you please explain each concept map draft and talk about the transition from one to the next'. Three additional questions were also asked if they were not answered in response to the primary question. These queried the feedback from colleagues during the workshop, whether or not they would recommend concept mapping to colleagues, and any perceived benefits or drawbacks of concept mapping.

Data analysis

Each interview was transcribed verbatim. The transcripts were reviewed to remove unnecessary spaces and all non-meaningful words. The transcripts were imported into a qualitative analysis software program, HyperResearch©, to be coded and analyzed. The interviews were coded thematically, using guidelines recommended by Miles and Huberman (1994) and Huberman and Miles (2002) for emergent themes. The unit of analysis was a complete thought: thus, one sentence may be coded as more than one complete thought, or more than one sentence may contain only one complete thought.

Coding procedures

Five of the interviews were coded twice by the first author, and an initial coding scheme was constructed. Two of these five interviews were coded by the co-authors, and an additional three interviews were coded by all three researchers, to establish consistency with the coding scheme constructed by the first author. As a result, adjustments were made to the initial coding scheme. Three more interviews were coded by all three researchers and a mean agreement rate of 92% was reached. The first author then recoded all 11 interviews using the revised coding scheme. In all cases, the entire interview was coded.

In many cases, the code name corresponds exactly with the words used by the interviewees. For example, we have the code names, 'bringing parts of the course together' and 'adjust the relative importance of course concepts'. The one exception to this was the theme coded as 'use disciplinary knowledge to inform the development of the concept map'. No interviewee specifically said these words, but the theories or practices they described were specific to their disciplinary knowledge.

The coding process resulted in 15 emergent themes. The themes were grouped according to the research questions, and further reduced to 12, because some of the themes were not directly relevant to the research questions. For example, references to departmental or university timelines and general statements about learners were not considered directly relevant.

The 12 emergent themes are named in Table 1 along with a short description, and, in each case, a direct quote from the interview data that was coded as that theme.

Table 1. Twelve emergent themes.

	Description	Example from interviews
Conceptualization of course content		
1. Rethink course concepts	Add, delete or clarify course concepts/ topics from one draft to the next.	ES: I tried to stick with the idea of centrality – then did this sort of outer ring – third [ring] – the ideas that I would hope that any student who takes an optics course will have understood [essential ideas], and then these things on the outer ring are things that really I could see that an optics course might leave out any one of them, because none of them are really essential for understanding the core ideas.
2. Change relationships of course concepts in map	Change shape Change order or placement of concepts Simplify by reducing text	HI: I think it's clearer to see these [concepts] as nesting. And also included is this experiment or physical process, which is actually why do we need the theory that we present … so actually we use it to model some experiments of physical processes.
3. Adjust relative importance of course concepts	Change the relative importance of course concepts from one draft to the next.	BJ: In other words, see what happened was I didn't really realize that it's the process that is emphasized because I thought these [the topics] are what are emphasized. The topics … they go through this process, so in terms of skills that I want them to acquire, it is really this [analytical] process or strategy, not this set of topics. So it didn't really kick in until I did concept mapping to realize this [analytical process] is what I want them to get.Not these [topics].
4. Bring parts of the course together	Bring aspects of the course together that were previously thought of or taught separately.	DP: I've got these individual strands, the kind of basic knowledge pieces that they need to develop and I understand that they need to weave these together to create something larger and more powerful that can be used in an integrated form to do something. I'm sitting here holding my fingers like this [like a rope] because I think I was actually seeing this to get those pieces together, these strands weave together into a rope … what I hadn't been able to figure out is how these other chunks, this developmental perspective and the evaluation components and thinking about evaluation differently relate to this. I go, oh well, that's what those do, they bind it together right, so then I come back and it's then relatively easy to come up with this next really rough design. … and that [image of the rope] really can be used to bind these individual pieces together.
Other course components		
5. Identify false assumptions about prior knowledge	Realize that assumptions about students' prior knowledge were unwarranted.	LM: I think there was a part of it that I always just said, no these kids should [already] understand why it is they need to know this … I shouldn't have to teach them that.

Table 1. *(Continued)*.

	Description	Example from interviews
6. Link other course aspects to new course conceptualization	Describe new or revised assignments or activities to fit a different conceptualization of the course. Change textbook, calendar description or title of the course to fit a different conceptualization of the course.	IL: I mean when I look back at the key concepts, it really is a how to course. You know how to engage family, how to talk to family. How do I represent those challenges, so how do I help them [the students] do that? And [before] I thought that the way to do that was to go from the theory, and it was very cerebral, it isn't experiential enough. Maybe you know something needs to change so that it goes from the experience to the theory. How do I do that? I am flipping everything on it's head. And I am not sure how to do that. It is something that's going to take a while, it may not happen all at once, I may just do little steps at a time and not … everything, because it can be a little overwhelming. But this is something that needs to change, I think the concept map and learning outcomes really brought that home.
7. Use of CM with students	Describe possible ways of using the concept map with students.	DP: Like I said, I've been pulling this [the concept map] out and putting it back every time we take on a new topic – where does it fit, why are we doing this – I've told them this is new, I haven't even used it before. The informal feedback is that it's very helpful. I feel like this course in the past has been a little bit like how my stats prof first described this first stats course I ever took. I remember this guy saying – all these pieces are going to dangle out here like loose strings for a while, and you are not going to see how they fit together, but trust me you are just going to have to have some faith in me. By the end of the semester they'll all fit together and indeed he was right about that – now that didn't ease our nerves, people were still fairly twitchy … Now I must say that I think that this [the concept map] makes it much easier to have faith.
8. Other uses of CM		AH: I guess especially in areas which are less young than computer science, where there is so much to learn – but if it's a research course then the goal is very different, you want to make them critical researchers, and so yeah I think a concept map has a deliverable. I think he [Andy] gave some examples of students drawing concept maps.
The CM process		
9. Engaging in CM process	Thinking about the CM process itself	IL: I guess the biggest difference between the two concept maps is that I started out thinking about the course in a fairly linear manner … But perhaps when I started out I was less secure, I was less confident and so I put things into boxes and said okay, maybe A will progress to B will progress to C.

Table 1. *(Continued)*.

	Description	Example from interviews
10. Impact of group interaction	Attending to feedback Influence of examples	AH: I think that in some sense the influence of seeing good examples [of facilitators and other participants], and of course of seeing people take a step back and reason about what they were doing – that had much more influence for me than the direct comments. So for me because of my discipline [Computing Science] the analogy of doing things visually [suggested by one of the facilitators] is the analogy of design. I'm also doing design so [I thought] maybe I should follow the same pattern [visual]. Right seeing how others were doing their own thinking.
11. Benefits of and problems with CM		DP: The concept map has helped me to convey to students the logic of this course. It has really helped me get a fix myself on how these pieces fit together. It has made a big difference to my own thinking, it is much clearer to me now … I have to say that and it has been useful in the most obvious way, [that is] conveying to students why I am doing what and when. They are able to have a sense in a way that they couldn't, just flat couldn't, in my earlier renditions of this course.
Disciplinary knowledge and design and representation of the course		
12. Use disciplinary knowledge to inform the development of the concept map.	Relate a theoretical perspective or professional practice to the course design.	ES: I think it was an aha. The idea of organizing it radially like this was I think for me very useful. Because at some level many courses in physics could be mapped onto a very similar structure – it's just that we tend to think more hierarchal – and linearly – and sequentially in that sense so in quantum mechanics that served me reasonably well and in optics, it didn't serve me very well. I found I had to backtrack and retrace and take digressions and those sorts of things.

Member checking procedures

We followed member checking procedures, as outlined in Lincoln and Guba (1985). During the interview, academics were asked whether they would like to review a verbatim transcript, or one that was edited to remove unnecessary spaces and all non-meaningful words. All indicated they would like to receive the edited version, as it would be shorter and more readable. These were returned to all participants to review and add to if they wished to do so; three of the eleven added to or clarified statements they made in the interview. We were also interested in their impressions of our 12 emergent themes, so we sent our initial analysis for their review; none of the participants suggested any changes to this.

Findings

The results of this study are reported in two parts. First, we provide three tables showing which themes emerged in each of the 11 interviews, and the frequency with which that theme emerged. The frequency of any one theme within an interview cannot be interpreted as being more prominent in the academic's thinking than any other theme. Likewise, the frequency of themes across interviews cannot be interpreted as having to do with the importance of one aspect (or theme) to one academic relative to another. We include frequencies only as a way of giving a basic idea of the distribution or pattern of themes within one interview, and across interviews, to substantiate our coding scheme. Second, we provide two examples of concept maps as a way to provide the reader with an idea of the overall evolution of thinking as experienced by two individual instructors. We think these examples provide a context within which the 12 themes are better understood.

Themes

The 12 themes are organized into four categories: three categories are represented in Tables 2–4. The fourth category – disciplinary knowledge and design – we discuss only in the text. Each table presents results within one category.

Table 2 reflects the importance of the concept mapping process in the conceptualization of course content. The second column of Table 2 simply indicates the number of drafts each participant produced. As can be seen, it was an iterative process for all, with more than half

Table 2. Conceptualization of course content.

	Number of concept map drafts	1. Rethink course concepts	2. Change relationships of course concepts	3. Adjust relative importance of course concepts	4. Bring parts of course together
(AH) Computer Science	3	7	3	1	3
(BJ) Business	3	2	2	2	2
(LM) Educational Psychology	4+	6	2	8	3
(DP) Education	4+	2	1	0	3
(ES) Physics	2	4	4	7	0
(FA) Medical Sciences	3	5	3	3	2
(GA) Library Sciences	3	2	1	1	1
(HI) Engineering	2	7	1	1	0
(IL) Social Work	2	2	1	1	3
(JP) Engineering	3	1	3	0	0
(KR) Psychology	3	2	2	1	1
Total		11	11	9	8

Table 3. Other course components.

	5. Identify false assumptions about prior knowledge	6. Link other course aspects to new conceptualization	7. Use concept map with students	8. Other uses of concept maps
(AH) Computer Science	0	0	2	3
(BJ) Business	0	0	3	0
(LM) Educational Psychology	1	10	1	0
(DP) Education	0	1	4	0
(ES) Physics	1	3	3	0
(FA) Medical Sciences	0	0	1	1
(GA) Library Sciences	1	4	3	2
(HI) Engineering	0	0	3	1
(IL) Social Work	0	4	2	1
(JP) Engineering	0	0	1	1
(KR) Psychology	0	0	2	1
Total	3	5	11	7

producing three drafts or more. All of the participants reported that the concept mapping process helped them rethink course concepts and the relationships among them (themes 1, 2). Almost all of them also reported that the process led them to adjust the relative importance of course concepts, and bring aspects of the course together that were previously thought of separately and not integrated with each other (themes 3, 4).

The influence of the process was reported by participants to extend to other aspects of the course they were designing, as well as, in some cases, beyond this specific course (Table 3). This is particularly noticeable in that all participants reported ways in which they would use the concept map with their students: for example, at the beginning of the course and during transitions in the course (theme 7). Apart from this, there was the realization by a few that some of their assumptions about students' prior knowledge and performance were unwarranted (theme 5). Some instructors also described how they would revise or develop assignments or class activities to fit the new conceptualization of the course (theme 6). Finally, some described how they would use concept maps in other courses or situations (theme 8).

The themes contained in Table 4 represent reflections on the concept mapping process itself. All but one instructor described what they were thinking or feeling as they created subsequent drafts of their concept map (theme 9). For example, one academic described how she gained confidence in her new perspectives about the course with each successive draft. All but one explicitly reported how group interaction and feedback supported the evolution of their concept maps and, by extension, their thinking about their course in

Table 4. The concept mapping process.

	9. Engaging in concept mapping process	10. Impact of group interaction	11. Benefits of and problems with concept mapping
(AH) Computer Science	3	9	1
(BJ) Business	1	1	4
(LM) Educational Psychology	9	2	0
(DP) Education	11	1	10
(ES) Physics	0	0	2
(FA) Medical Sciences	11	6	4
(GA) Library Sciences	4	6	1
(HI) Engineering	6	1	3
(IL) Social Work	4	5	0
(JP) Engineering	5	3	6
(KR) Psychology	3	1	2
Total	10	10	8

general (theme 10). More than half reported the benefits of the process in helping them think through the content and why they might use it again (theme 11).

One theme emerged in the analysis that at first we did not recognize as being directly relevant, yet we found it extremely interesting. This theme had to do with using some aspect of disciplinary knowledge (for example, a particular theory that informed an academic's research), or way of representing thinking (for example, a notation system used in computing science), to inform or make sense of the development of the concept map (theme 12). This theme emerged in six of the eleven interviews.

Concept mapping examples

The remainder of the article presents two examples of concept maps developed by two of the academics who were participants in this study. Each example attempts to provide for the reader a more complete picture of the evolution of thinking, as experienced by two individuals, across concept map drafts. One can see in the comments of each academic reasoned and intentional decision making about course content and student learning, and how reflection prompted this development.

These particular interviews were selected because they represent quite different fields (business and computing science). For each example, two of the concept mapping drafts are included as figures. In each case, these two drafts were chosen out of the total number of drafts produced by each instructor because either they reflected the most change or the most significant changes, as referred to by that individual.

Example 1: computing science

Figures 1 and 2 are the second and third drafts of a concept map representing an undergraduate course in computing science. In each of the instructor's (AH) three drafts (the first draft is not shown), the concept of design becomes more and more centrally placed, and more linked to other aspects of the concept map. AH identified this as well:

> So I think that the two major leaps were putting design central and sort of unifying everything which was there in draft two … In the center you have design, it's a course about design and then it radiates out to the different sites, and now it's very clear that design of object-oriented software always meets quality criteria, otherwise you can't assess whether it's good or not … and this was the nicest addition I think, the fact that I have explicitly put something called quality criteria here, and that I have lumped reuse and consistency [from the second draft] under it. So that was not at all like in draft one, they were rather independent [in draft one]. They are independent chapters [in the textbook I use], well it's more than chapters it's like three main parts of the course, but the big picture, how everything is grouped together, was there implicitly but never explicitly and now it's there explicitly.

AH struggled to decide what was essential to include in his concept map, and what was important but not essential. He had to make, in his words, 'tough decisions'. Then he found a way around this by beginning to think of the concept map specifically from the perspective of a computer scientist. He realized that he could include more, but that it would not be stated in words on the concept map. Rather it would be depicted through notation (i.e., arrows, circles, graphics – see Figure 2), notation that has a particular meaning for computer scientists. He describes his decision to include the notation:

> In computing science, partly because your ultimate goal is to actually implement something, if this [the concept map] was a design of a piece of software, [then] you have to be very explicit about what everything means because notation is just notation … So somehow it's by the analogy of doing things visually, the analogy of design, well I'm also doing design [in designing this course], so maybe I should follow the same pattern.

AH directly attributed two of the changes he made in his concept map to, in one case, the feedback from and discussion with members of his small group, and, in the second case, the presentation of one person in the small group. AH seems also to have gained, in other ways,

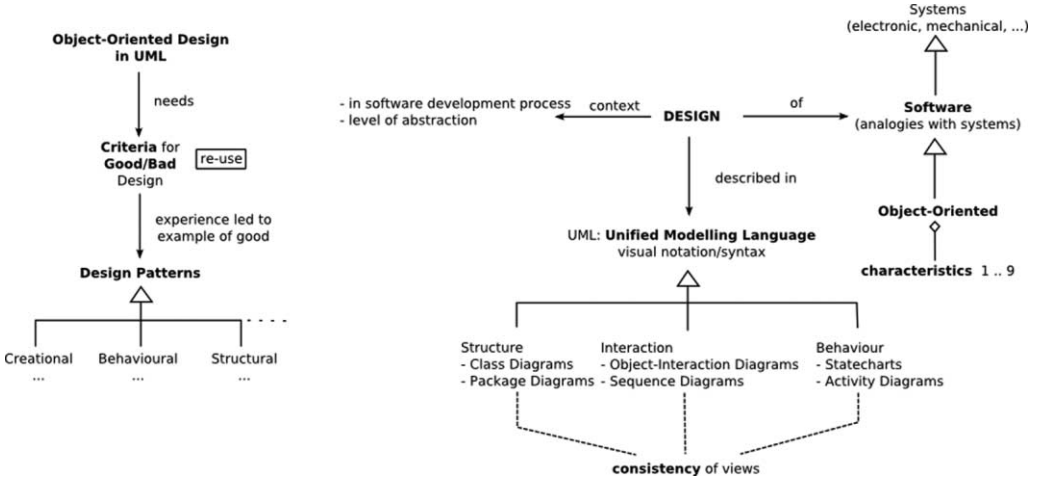

Figure 1. Second draft – computer science course.

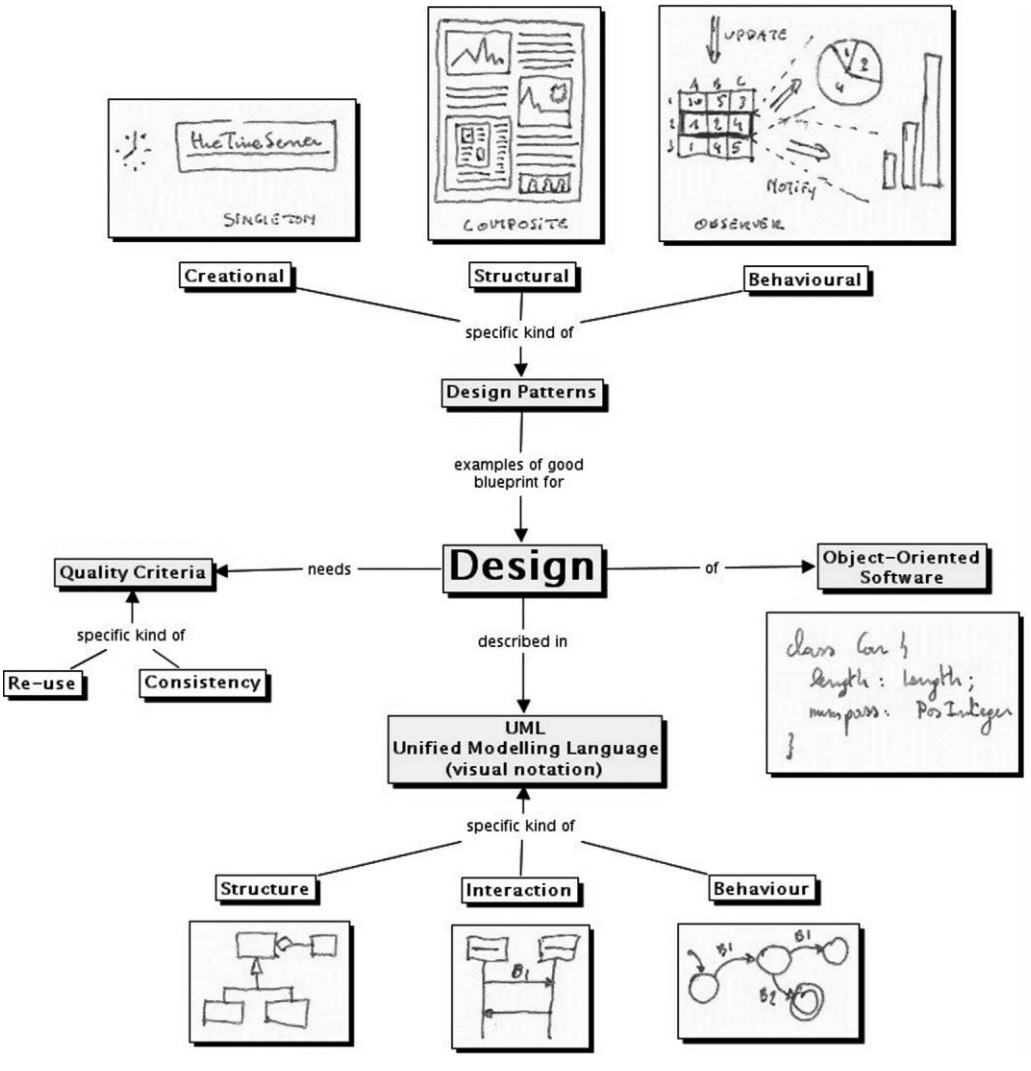

Figure 2. Third draft – computer science course.

from the presentations in the large group setting of the workshop, and his interactions in the small group. Here he reflects on the power of what he observed:

> the wonderful visual examples I saw, the presentations. E [co-instructor in the workshop] said that she tries to do everything, which can be done visually, she does visually, and it really makes sense. I'm trying to do that now even in my current map [referring to the notation in his map] … I think that the influence of seeing good examples and, of course, of seeing people take a step back and reason about what they did – that had much more influence than the direct comments [to me].

Example 2: business and management.

Figures 3 and 4 represent the first and third drafts of a concept map representing an undergraduate course in business and management. The instructor (BJ) had just one year of

teaching experience when she enrolled in the course design workshop. BJ's first draft was divided into two parts (Figure 3). One part was simply the five major topics (aspects of marketing strategies) to be covered in the course, and the second part was what the students had to do, which included marketing strategy exercises and market reports. Upon reflection, she stated: 'There are three different facets of the course and I had difficulty incorporating them'.

In her second draft (not shown here), BJ began to think of the content of her course in a more integrated way. In the third draft (Figure 4), she decided to create something completely different. She began to focus on an analytical thinking process that she decided was the most central aspect of the course. She explains how her thinking changed between the drafts and why:

> I was thinking how I could – this is like a flow chart. I was thinking how I could put it [the analytical thinking process] together … In other words, what happened was I didn't really realize that it's the process that [I wanted to] emphasize, because before I had thought these are what are emphasized – the topics [as listed in Figure 3). But the students, they don't really discuss these topics. They go through this [analytical thinking] process, so in terms of skills that I want them to acquire, it is really this process, not this set of topics. It didn't really kick in until I came to this workshop to realize this is what I want them [her students] to get, not these [the topics].

She further realized that this analytical thinking process was one that students could use over and over with the different cases they read: in other words, they could practice this same analytical approach in different marketing contexts. She added, 'It's a learned skill, it can be learned'.

Early on in the workshop, BJ began to think about using her concept map with her students. In the end, she decided to include her concept map in her course syllabus, so

Figure 3. First draft – business course (original draft constructed with post-it notes).

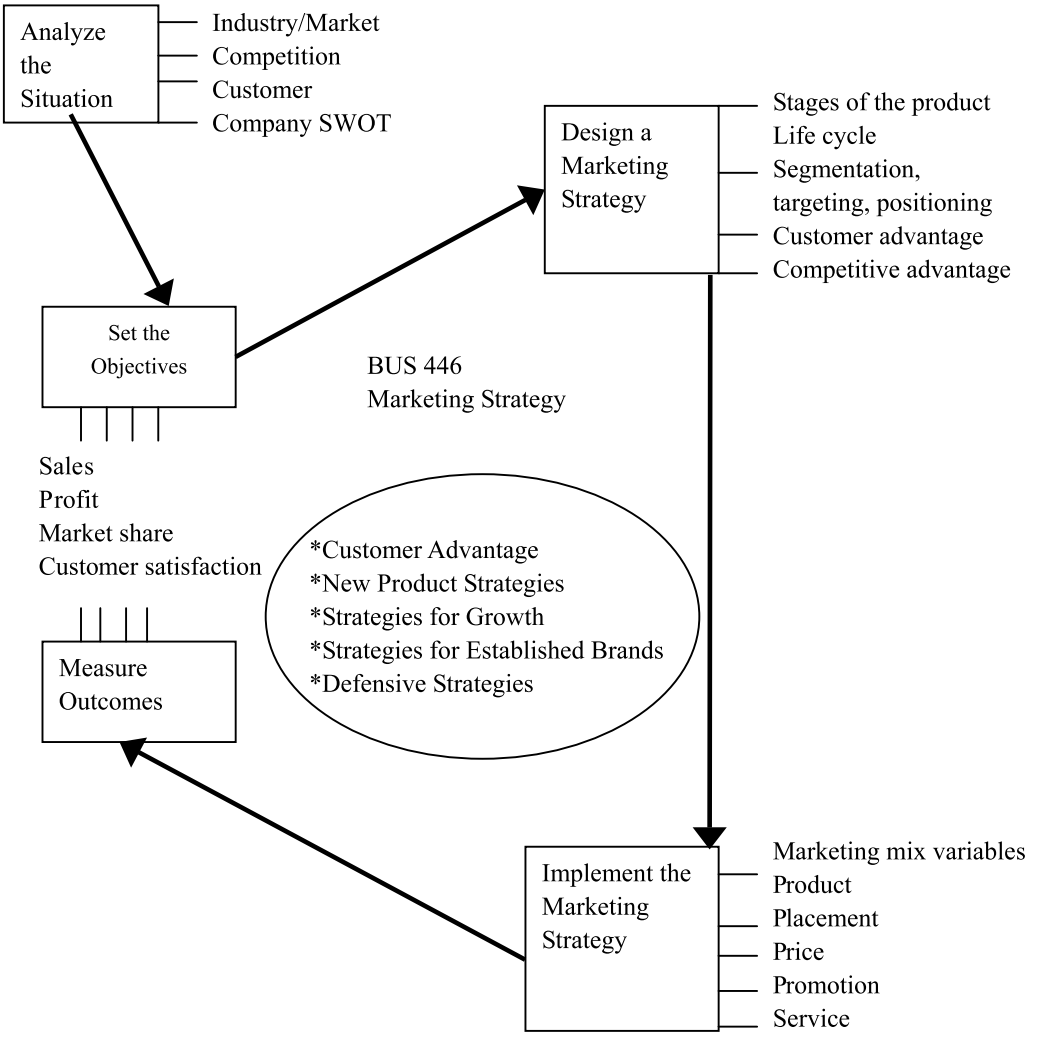

Figure 4. Figure 4. Third draft – business course.

that she and her students could refer back to it repeatedly. She explains her decision as follows: 'I guess in terms of communication, I never really communicated this to my students. … I had this picture in my head, but I never explicitly told them this is what I had in my mind'.

In terms of the concept mapping process she engaged in, BJ explained:

> I guess the longer I'm in academia, the more I realize a different way of thinking makes a big difference. You can think the same thing different ways and you can visualize things in different ways and you get different inspirations, you have different ideas. So I think having this concept map sort of helps me look at the course in a slightly different way and that's good, that's refreshing. And all it takes is just one diagram, and that's it … but I also realize habits are very difficult to break. We are used to doing things the same way over and over again. I mean it [concept mapping] takes a little bit of getting used to, of course. … Yeah, it's [concept mapping] quite amazing … if you just put things, you know, in the diagram, somehow that sheds new light to it.

Conclusion

Our primary goal in working with academics is to support an intellectual process of close examination of instructional decisions, making explicit the rationale and intentionality underlying those decisions. The concept mapping process is intended as a way for academics to clarify and to better understand the content of a course, and is a first step, we suggest, in the examination of instructional decisions. Throughout this process, an instructor's subject matter understanding is probed and serves as a firm reference point for the appropriateness of decisions made. In this study, we investigated two questions: (1) How do university academics explain the changes they make to successive concept mapping drafts, and the implications of these changes for the course they are designing?; and (2) How do university academics describe the process they engaged in to develop the concept map, and in particular how they incorporated peer feedback?

Our findings addressing these questions show that concept mapping, as a first step in the course design process, provided an alternate means to determine or rethink course content, one that highlighted relationships among concepts, encouraged a view of the course as an integrated whole, and frequently provided the occasion to make explicit the types of thinking required in the course. Taken together, these aspects (concepts, relationships among concepts and methods and modes of thinking) form the foundations, as has been suggested (Donald 1983, 2002; Hirst 1974), of what constitutes knowledge in a discipline. It follows that these foundational ways of conceptualizing knowledge form the basic structure, or the basis of knowledge in any given course in higher education, and that this structure, within a specific disciplinary context and subject to an instructor's unique organization of it, has direct implications for teaching and learning (Neumann 2001).

We also examined the function of reflection in the development of concept maps, reflection that in some instances was directly prompted by peer feedback. The importance of feedback from group members in the workshop, in terms of the ongoing development of the concept maps, was specifically discussed by 10 of the 11 academics. For several of these individuals, the feedback and their reflection on it was credited with being the impetus for major changes in their concept maps, and thus in the conceptualization of their course. Rowland (1999) suggests that critique is fundamental to academic discussion, and critical to fostering understanding, because it allows different disciplinary values or underlying theories to emerge.

Brew (2003) proposes that variation in academics' conceptions of knowledge and research has consequences for the relation between teaching and research, yet, as researchers, we rarely have the time or perhaps the inclination to examine our teaching decisions in relation to our conceptions of knowledge in our disciplines. McAlpine, Weston, and Beauchamp (2002) proposed that, as academics, we could explicitly construct and analyze our scholarly activities from the perspective of learning. Our intention is to engage academics, as teachers and researchers, using concept mapping and other activities, in making explicit their taken-for-granted theories of learning and teaching in relationship to their subject matter understanding.

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Appendix. How we suggest instructors develop their concept maps

Background

We use an unstructured form of concept mapping to allow the utmost freedom for instructors to represent their thinking. The purpose is to uncover the instructor's thinking about the overall concepts in the course, the nature of the relationships between these concepts, and the course as a whole. Therefore we pay attention to both the internal integrity of the concept map (the representation of concepts themselves and the links between them) and the external integrity (the overall structure and shape of the concept map). In each of our workshops, we invite one or two past participants (from distinctly different disciplines) to come and show current participants how their concept maps developed from first draft to current draft. This way, current participants see that a process is involved, one that may be ongoing as individual instructors refine their thinking about the content of a particular course. They also see examples of concept maps that look very different from one another, which tends to communicate that there is no one way to do this task, but rather it should be a representation of individual thinking.

Suggested process

In small groups of six, we introduce the following steps that participants can follow to develop their maps. This progression suits most participants, although some participants choose to go about it differently.

(1) Write down everything that comes to mind that you consider important in the course you are designing.
(2) Go back and read through what you have written and try to reduce the number of ideas or concepts by circling those you consider most important.
(3) Write each of the circled concepts on a post-it note.
(4) Sort the post-it notes into meaningful clusters or groupings.
(5) Label each cluster and write the labels on a post-it note. These labels will probably reflect the key concepts you will use in your map, but this may change.
(6) Arrange these labels (key concepts) in a way that is meaningful to you.

The progression above yields a first draft. Workshop participants typically make several revisions of their first draft based on their own insights, and from the feedback of others in the workshop. This feedback process is usually an important and obvious impetus to individual thinking, since others in the small group are generally from other disciplines (although we also have adapted this workshop for groups of academics from the same discipline), and can comfortably ask 'naive' questions that help individuals perceive how learners might make sense of the subject matter. The resulting concept maps may be like the more structured, hierarchical, upside-down tree or cluster formats described, or they may begin that way, but evolve into circular, triangular or three-dimensional shapes or be depicted as a metaphor. As the reader probably already realizes, the process of developing the concept map (which often goes on long after the end of the workshop) is as important as the map itself (Freeman 2004). Whatever the visual organization of the concept map, the true test of its comprehensiveness, we believe, is that an academic can see every element of his or her subject matter relevant to the course in the map, and can use it to effectively describe the course to someone else, ideally to students.

Note: We have available several computer-based concept mapping software programs for participants to use, but most tend to begin with hand-drawn maps, and many then draw later drafts using computer-based tools. A number of participants have told us that they feel that computer-based concept mapping is too constraining in the initial development of their concept maps.