Representing the dynamic complexity of students' mental models of learning in order to provide 'entry points' for teaching

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Students' prior knowledge about learning mediates their more or less successful engagement with learning in the various subject matter domains. Therefore, in order to inform teaching practices that are attuned to the different learning needs of individual students, teachers require sensitive, nuanced representations that capture the complexity and fluidity of individual student's mental models about learning.

We collected focussed written responses and interview data from primary, secondary and tertiary students about their knowledge about learning. We represent students' knowledge using theoretical frameworks, text extracts, flow charts, concept maps and tabulations. We highlight that students possess knowledge about learning that is often underdeveloped, but that nevertheless contains potential 'entry points' for teaching that can be used to facilitate the construction of more generative mental models about learning.

Introduction

> **Mya** (teacher education student): Writing something down makes me remember it more. If I have to learn a phone number, if I write it down, then I can remember it a lot better. Sometimes I think it's funny because it's a bit of—I can't think what the word is—like if you take a note you will remember it anyway without needing to read the notes, but if you don't take the note, you don't remember it and you wish you had.
>
> **Interviewer**: Do you have a theory … why it's like that?
>
> **Mya**: I just think it's a memory thing, it's a brain thing, something about the way your brain works. Like my mum always said if she says to me, "Oh, can you remind me to do something,", it doesn't matter whether or not I remember to remind her because the act of asking me to remind her, makes her remember. So how your head works and how you remember things, I'm not sure exactly why. It just is.

An important implication of contemporary constructivist philosophies of learning is that teachers need to pay heed to the prior knowledge that students bring to instructional environments. This includes students' prior knowledge in subject domains, such as science or music. Teachers must also pay close attention to their students' prior knowledge in the domain of learning, as students' knowledge about learning mediates their interactions with subject matter (Winne & Marx, 1980, 1982).

Our research program focusses upon students' knowledge about learning. Some students we have interviewed, including Mya, quoted above, have not found it easy to describe their knowledge of learning in an explicit manner (Askell-Williams, 2004; Lawson, Askell-Williams, & Murray-Harvey, 2003) Mya knows that 'writing something down' helps her to remember it. But when pushed for an explanation as to why this might be so, Mya cannot generate a detailed explanation of her thought processes. We propose that such a lack of knowledge about learning places Mya in a less favourable position as an active, self-directed, lifelong learner than she could be if she had a well developed mental model about learning at her disposal (White & Baird, 1991). Furthermore, given her planned profession as a teacher, Mya's lack of knowledge about learning presents a double deficit, in that if her own mental model of learning is sparse

and poorly connected, then it is unlikely that she will be in a position to facilitate the development of robust mental models about learning in her prospective students (Feiman-Nemser, 2001; Shulman, 2000).

Other researchers have also raised concerns about the quality of students' knowledge of learning. For example, Elen and Lowyck (1999) observed that, although their participant undergraduate teacher education students possessed a range of relevant professional knowledge, the students lacked systematic vocabularies about instruction, and did

> not seem to have articulate conceptions about the way in which an instructional environment may support their cognitive processing and/or control activities. (p. 157)

Woolfolk-Hoy and Tschannen-Moran (1999) also worried that their student teacher participants lacked

> understanding of the connections between teaching strategies and students' learning … our students have great difficulty explaining the mechanism of learning and how teaching influences these processes … Few students are able to connect the activity to cognitive processes that lead to learning. (p. 280-281)

In classrooms, teachers must not only be able to help each student when the student asks to be shown how to solve a particular problem: Teachers must also be able to help students to learn in a way that will allow students to solve different but related problems, and perhaps problems in a different area of the curriculum, or in different situations throughout their lives. In other words, teachers must work with students to enable the students to transfer their knowledge: preferably to transfer across significant situational and temporal distances (Bransford, Brown, & Cocking, 2000). If such transfer is to eventuate, teachers need to work with their students to enable them to develop sophisticated knowledge of motivational, cognitive and metacognitive processes in learning (Mayer, 1998) through explicit instruction (Bransford et al., 2000).

When students have such knowledge, the benefits for their learning about topic domains can be considerable (Hattie, Biggs, & Purdie, 1996; Mayer, 1998). For example, Luyten, Elen and colleagues (Elen & Lowyck, 1998, 1999, 2000; Luyten, Lowyck, & Tuerlinckx, 2001), investigated college students' metacognitive knowledge about instruction and instructional environments. Luyten et al. (2001) found a significant relationship between the sophistication of students' perceptions of instructional tasks, and their planned and executed learning activities. To effect substantial transfer of learning, both teachers and their students need to have a good understanding of contemporary learning theory. And in order for teachers to develop their students' knowledge about learning, teachers need information about the state of their students' knowledge about learning.

The research literature contains a number of different ways of representing students' knowledge about learning, including frameworks of epistemologies (Perry, 1970), conceptions of learning (Marton & Saljö, 1976a, 1976b); approaches to studying and learning (Biggs, 1979; Entwistle, Hanley, & Hounsell, 1979), attributions for success and failure (Graham, 1991; Graham & Weiner, 1993), mastery and performance achievement goals (Ames & Archer, 1988; Pintrich, 2000; Pintrich & DeGroot, 1990) and self-theories of intelligence (Dweck, 1986, 1999).

Although such frameworks are useful for characterising students' knowledge about learning at a broad level, say across large groups of students, or across whole courses of instruction, we consider that more sensitive and nuanced representations are required to capture the complexity and fluidity of individual student's mental models. In particular, the tendency of broad level frameworks to polarise students' knowledge into categories (such as 'surface' or 'deep' approaches to learning; or 'mastery' or 'performance' goals) fails to account for the complex, transactional nature of students' mental models about learning. Such transactions, or reciprocal interactions, occur in three ways:

Within different components of each student's mental model of learning, such as between motivations of interest and perceived future value; assessments of self-efficacy; prior knowledge; and metacognitive knowledge (e.g. Wigfield & Eccles, 2000).
Between the student and each situation, for example, as students move between different learning environments such as between classrooms, between home and classroom, or between classroom and work, where students may be exposed to a range of learning cultures and learning demands (e.g. Lave & Wenger, 1991).
Between each student's knowledge about learning, and his or her knowledge about subject matter, such that what evolves from an interaction between the two knowledge domains is an evolutionary step that goes beyond simple knowledge about one or the other (Veenman & Elshout, 1999).
There is a gap in the literature that attempts to represent students' knowledge of learning. This gap appears at the point where such representations need to be sufficiently fine grained to capture individual differences both in degrees of complexity and in variations in students' responses to situational affordances and constraints. Such fine grained analyses are necessary in order to help teachers to diagnose and provide instructional interventions that are sensitive to the needs of particular students.

Thus, in this paper we report findings from analyses of in-depth investigations with a range of students, and present a variety of ways of representing the complexity of the students' knowledge about learning. Leading from that, we make suggestions about ways to harness students' knowledge about learning as potential 'entry points' that teachers might use to facilitate their students' development of more robust mental models about learning.

Method

We conducted a series of conceptually linked studies from 1999 to 2004 in South Australia. We were keen to access students across a broad age range, and also across different life circumstances. As such, participants were drawn from primary, middle and secondary school classes, basic tertiary level courses in child-care and university foundation (pre-entry) studies, undergraduate and graduate entry teacher education, and graduate medical education programs. Sixty eight students attended extended interviews and 413 students provided written responses.

Students' ages ranged from 8 years to mid 40s. Students were predominantly of British and European heritage and from low to upper socio-economic status. Many of the adult students possessed extensive employment histories.

The response formats

Data was collected in three forms.

1. Short written responses to a focus question—approximately half a page in dot point form.
2. Extended written responses to one or more focus questions—one to two pages.
3. Extended interviews to a series of focus questions—ranging from 20 to 90 minutes.

The focus questions

As our program of research developed over the six years, and as preliminary findings began to emerge, the focus questions put to each of the participant groups evolved. For example, in 1999, students were asked to respond in writing to the question 'What are the features of interesting class lessons?' whereas in 2004, students were presented with short scenarios, and asked to describe how certain actions by their teacher (such as giving a lecture) and by themselves (such as contributing to a class discussion) could facilitate their learning. A complete list of the focus questions presented to each participant group is included at Appendix A.

All written responses and audio-taped interviews were transcribed. NUD*IST (QSR, 1997) data analysis software was employed for coding and sorting participants' responses. The interview transcripts were subjected to iterative reading and thematic interpretation by the researchers though extensive discussion, external reference to the teaching and learning literature, and internal cross-checking to the complete contents of the transcripts.

Results

Building on prior knowledge

Let us return to Mya. In the introduction to this paper, Mya appeared to have little knowledge about processes of remembering, saying

> So how your head works and how you remember things, I'm not sure exactly why. It just is.

However, when she was pressed further, Mya did proffer some knowledge about learning. In Table 1, we have taken a portion of Mya's interview transcript and aligned her comments to key ideas in contemporary instructional psychology (for example, Anderson, 2000; Bruning, Schraw, Norby, & Ronning, 2004).
We see from Table 1 that Mya lacks the technical language to equip her to engage in an in-depth discussion about learning. She has some knowledge, but it is not readily accessible, and it is not well-developed. In a sense, Mya possesses a low level of "learning literacy".

Table 1: A portion of Mya's (2nd year teacher education) interview transcript aligned to key ideas in instructional psychology

Mya's Statements	Links to instructional theories
Yeah, it probably contributes to your remembering it too because you immediately – as opposed to someone saying something to you go, oh, that's	

really interesting … and in the back of your mind you pull out what you find interesting about it – if you can write it down then it immediately brings it to the front and brings our the key points in it or whatever it was that made you get drawn to it.	Activating personal interest Focusing attention Connecting to prior knowledge
The other thing is, even if it's maybe not even especially relevant, it can sometimes just encourage acting – encourage you in taking notes because actually taking the note can make you become more interested in the topic because you feel, maybe personally I feel like if I'm writing something down then I must be getting somewhere because I'm making enough sense of something to… remember that thing.	Active engagement Notetaking strategy Metacognitive strategy awareness Situational interest Self-monitoring understanding
My dad's … a reptile curator in the museum so it's always about lizards and things I saw him speak once and he said that people talk about reptiles being cold-blooded but he thinks that they're solar powered – and it's things like that that can put things in a nutshell and make it make sense.	Using metaphor to illustrate meaning Metacognitive awareness of the power of metaphor

However, expressed in her everyday language, Mya does possess the rudiments of some key ideas about learning. We have interpreted Mya's ideas, using contemporary theoretical frameworks, in the right-hand column of Table 1. For example, Mya has the beginnings of a 'mini-theory' about personal interest and situational interest, and their effects upon attention and engagement (Hidi, 2000). She also acknowledges a key self-regulatory strategy, in that she self-monitors her understanding (Zimmerman, 1989, 1990, 2002). And she appreciates the conceptual power of metaphors for helping to understand new ideas.
Our reading of the interview transcripts suggests that many students show knowledge profiles that contain key ideas, but that have similarly undeveloped conceptual potential.

Students statements about self-regulation

Our overall assessment from participants' responses is that self-regulation, incorporating self-motivation, behaviour management and cognitive monitoring (Garrison & Archer, 2000; Schunk, 1995; Zimmerman, 1990, 2002) was well-recognised by participants as an essential prerequisite for effectively engaging with learning opportunities. For example, Amber (foundation studies) made the following observation about the role of the student's motivations in engaging with learning opportunities.

> Amber (foundation studies): The responsibility for learning lies 90% with the student; the teacher can stand up there and give the best lecture ever; if you aren't 100% switched on to learning; you're not going to learn a damn thing; you can get a lot out of a bad lecture if you are turned on to learning from it; you go out and find the information you haven't been given; ask the questions you need to ask; preparation work.

Indeed, the teenage and adult students nominated several diverse components of self-regulation, such as time management and asking questions to gain knowledge and facilitate understanding. Although the primary school students spoke less about specific strategies for self-regulation, the general impression was that the sense of 'I'm responsible for my own learning' was well established across all participant groups. A selection of self-regulatory statements are represented in Table 2, which was collated from interviews with four Year 11 students. Table 2 includes the categories "I'm responsible", "Time management", "Ask questions", and "Do the work", which are key components of self-regulation.

Applying a theoretical structure of self-regulation

There is scope for further developing students' knowledge about self-regulation. Figure 1 displays a flow chart of a short excerpt from Sam's (final-year teacher education student) interview transcript, which we have coded into categories taken from Zimmerman's (1998) model of self-regulatory processes, namely, forethought, performance control, and self-reflection.

Table 2: Summary of four Year 11 students' statements about self-regulation

Categories	Donna	Dianna	Alistair	Freda
I'm responsible	you really have to help yourself; our choice to work; don't work then don't learn	I'm responsible because it's my learning; if I'm really interested in learning I have to pay attention	I help myself to learn; if I'm not paying attention I can't learn	
Time management	I like to have the work finished early; don't have to worry about it at the last minute; hand it up early	work out what nights to do the homework; to get the assignments done; work out how long to spend on each thing; try to keep up with all of the work; work on getting certain things done by certain dates	make sure I'm on the ball; that all my work gets handed in; that I don't get behind; try to get it in	force myself to do it; sometimes I put the music on the table and play even when I don't want to; Students can get to do this if it is their free choice; at school it would be different; you have to do school – you don't have the choice
Ask questions	ask her [teacher] for help if I don't understand; I usually don't have a problem		check with the teacher; find out what I need to do then do it	
Do the work to learn	you have to do the work; you learn from doing the work; if you don't do the work then you're not taking control of	Get the work done; don't slack off and not do anything; which you're not going to be learning much; I help myself to learn; by		I learn it by myself; get the information & do what it says [cooking, recipes]

	your own learning	doing the work		

The theoretical organisation of Sam's statements facilitates further analysis of Sam's mental model about self-regulation.

Forethought
Goal setting
Strategic planning
Self-efficacy beliefs
Goal orientation
Intrinsic interest

Performance control
Attention focussing
Self-instruction/ imagery
Self-monitoring/ metacognitive awareness
Self-reflection
Self-evaluation
Attributions
Self-reactions
Adaptivity

Actually explore issues

Sometimes I get the wrong idea
Nice to clarify what they're aiming at

[in tutorial] I can ask questions

[in tutorial] I can follow different pathways

I jot down points

Explore in more depth

I can say 'Is that right?'

[doesn't] satisfy me
It's too low level

I didn't agree with what they were on about

I like to look beyond…ask why did they look at that area So I can get a big picture of what they're trying to get at

Allowed me to look at other people's point of view
And understanding that's only one view…made me realise it was fine…it wasn't that I was wrong

You get information to write [the] essay and understand the topic…find more information for yourself
Listen to what other people have to say

Gave me a better picture of what we were looking at

Made me feel more comfortable

Figure 1: Portion of Sam's interview transcript coded to Zimmerman's categories of self-regulation

It can be seen from Figure 1 that statements have been categorised into all three stages of the model. Sam expresses goals, such as 'explore in more depth', and 'I like to look beyond.'

He monitors his comprehension, by asking himself 'Is that right?' And he shows awareness of his self-reactions, in feeling 'more comfortable'. Our assessment, however, is that Sam does not appear to have organised his thinking about learning into a conceptually coherent model of learning. He has individual "nodes" of knowledge, but the power of his mental model for generating effective learning actions would be enhanced if his metacognitive awareness about learning was more explicitly structured according to a theory such as Zimmerman's framework (Karmiloff-Smith, 1992).

Accessible representations of the complexity of students' mental models

We were also interested in finding economical ways of concisely representing larger tracts of participants' responses. We exported the results of coding the interview transcripts (using NUD*IST data analysis software) to Inspiration (Helfgott & Westhaver, 2000) display software, to generate compact visual displays of the contents of participants' transcripts. For example, Figure 2 represents Josi's (medical student) knowledge coded to the major category "constructing knowledge". The statements to the right of the diagram are summary extracts using Josi's own words.
From Figure 2, it appears that Josi adopts a deep approach to her learning (Biggs, Kember, & Leung, 2001). For example, she 'joins categories together,' 'makes things into real life,' and 'assimilates a broad understanding.' However, Figure 2 also contains statements where Josi told how she 'swats like mad' as part of accumulating knowledge, and that swatting provides her

with the information she needs to allow ‘new understandings to open up.’ Swatting conforms to what is known about forgetting, in that ‘some goes away,’ but Josi understands that when the time comes for her to ‘use it again’ she will ‘remember more’ and that she will not be ‘trying to understand it the next time.’ Nor does she have to remember it all; as long as she understands the principle.

Josi commented that the plan is to ‘have it all in your head at once,’ that is, the swatted knowledge, the broad understandings, and the real life. The format of the representation of Josi’s statements in Figure 2 would suggest that she is both adopting a deep approach to learning and using strategies such as swatting, which would traditionally be conceptualised as being more typical of a surface approach to learning.

Figure 2: Josi’s statements about “Constructing Knowledge

Josi
The nature of teaching & learning
Make summaries
Think what is the best way to do this?
Join categories together
Do it yourself
Exposes the gaps
Assimilate a broad understanding
Have it all in your head at once
Make into real life
New understandings open up
Swatting like mad
Treat patients better
Interrelationships make more sense
Sit down
Some goes away
Patients make more sense
Constructing knowledge
Learn
Remember
Relate to other things
Not all goes away
Use it again – remember more
Don’t have to remember everything
Recognise 70%
Remember 30%
Revisit each year
Understand principle
Sometimes tip of tongue
Remember common stuff
At deeper level
Already familiar
Not laying pathways-learning words
Look it up
Answer a question about it
Apply it to a patient
Note trying to understand the next time

As a group, the medical students spoke of other strategies that could be categorised as characteristic of surface approaches, such as reading over and over, repeat without looking, memorising and practising the items on competency checklists. For example, in Bigg's (Biggs, 1987; Biggs et al., 2001) revised Study Processes Questionnaire (R-SPQ-2F) item 8, which refers to rote learning, is a surface strategy item:

I learn some things by rote, going over and over them until I know them by heart even if I do not understand them. (Biggs et al., 2001 p. 148)

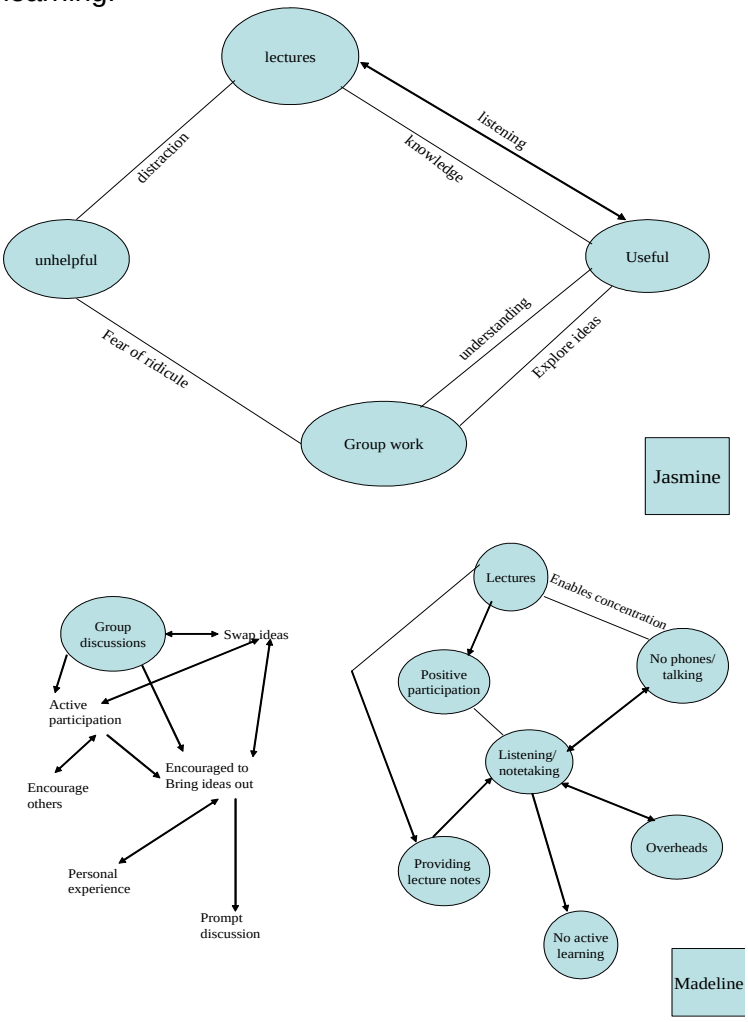
However, in the present study, such surface strategies are intertwined with participants' deep approaches to learning. Indeed, John (medical) lamented that he was 'a hopeless rote learner,' for he considered rote learning to be an efficient strategy for mastering the extensive body of facts required for him to progress in his medical studies. This raises a question about how we characterise learners at the individual level. For example, which part of Josi's or John's mental models about strategies for learning would be activated if they were to complete a relatively short assessment such as the SPQ? 'Swatting like mad' or 'assimilating a broad understanding?' Would Josi be classified as a person with a surface, or a deep, approach to learning? When designing teaching interventions, it would be more effective at the individual level to make full use of the complexity in Josi's account of her knowledge about learning, rather than to position Josi at just one pole of a surface-deep dichotomy.

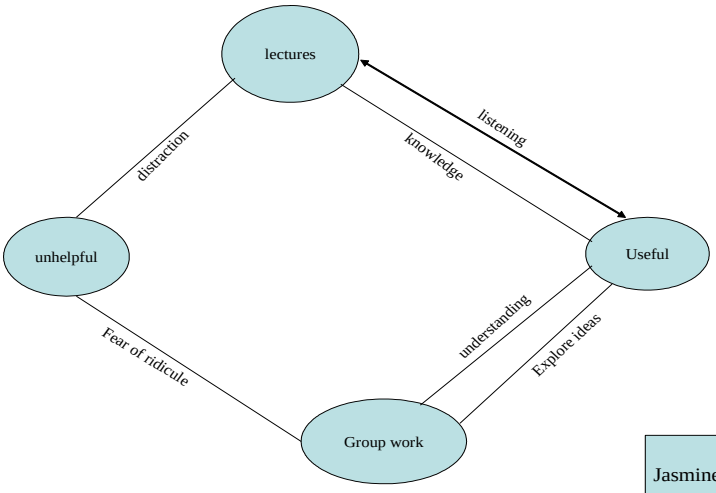
Students' concept maps of their mental models

Another way to generate visual displays of students' mental models is to ask students to draw concept maps to represent their thinking.

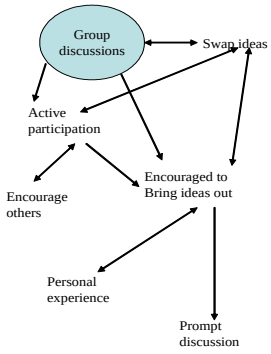
We provided second year teacher education students with training in the concept mapping technique, and then asked them to 'draw a concept map that displays how the ideas you have written about are related to each other.' We were particularly interested in identifying the links

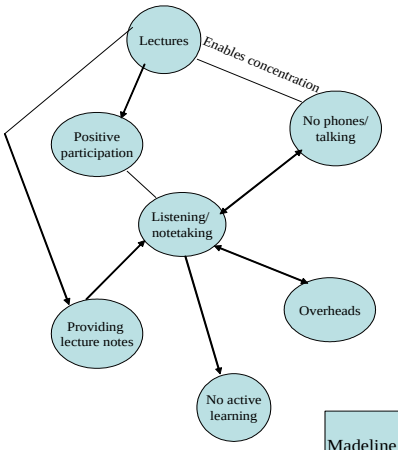
that students made between different parts of their knowledge, as a well-linked mental model is theorised as being more accessible, and more able to generate action (Anderson, 2000; Bruning et al., 2004; Wittrock, 1990).
It is striking to note the differences between the students' representations of their mental models. For example, in Figure 3, Jasmine provides a relatively sparse map, arranged in a circle, with six named links. She opposes the two main themes identified in her written response, lectures and group work, at the north and south poles, and useful and unhelpful at the east and west poles. She connects the node lectures, via the links knowledge and listening to the node useful, and she connects the node group work via the links understanding and explore ideas to the node useful. Knowledge and listening can be conceptualized as relating to a transmissionist conception of teaching and learning, while understanding and explore ideas can be conceptualized as a more constructivist conception. That both transmission and construction are linked to useful suggests that Jasmine is making use of both these different conceptions of learning.





Jasmine





Madeline

Figure 3: Second-year teacher education students' concept maps

In contrast, Madeline drew two separate circles, the first headed by the node group discussions, and the second headed by the node lectures. During her extended interview, Madeline was asked if there was any connection between her two circles, and she stressed that there was not and, even after considering it again, she was unable to join the two. It appears that Madeline does not conceptualise that she can take the information transmitted in lectures to a forum such as a group discussion in order to cognitively work upon that information so that she can further develop her understandings. In a university setting, if the links between the lecture format and the discussion format have not been made explicit to Madeline she is likely to be at a learning disadvantage.

A sample of students' written responses

Two prompts that we gave to a class of Year 12 students were, 'In mini-lectures, what can other people/resources do to help you to learn?' and, 'How does this help you to learn?' Table 3 contains a summary of the students' responses, which ranged from impoverished to extensive.

From Table 3, it can be seen that students 3 and 10 recognise that the teacher is a source of expert knowledge; students 3, 9 and 13 appreciate the value of the teacher recounting an anecdote or relating the topic to real life; students 1, 3, 7, 9, 11, and 13 propose strategies that facilitate elaboration of information to facilitate memory; students 3, 6, 8, and 12 appreciate the enhanced learning that comes from reviewing information via two modalities, verbal and visual; and students 1, 3, 4, 5, 6, 7, and 11 stress the importance of the teacher keeping the material interesting with enthusiasm and tone of voice. Indeed, as a class, the students could put together a reasonable primer in instructional psychology! It would be very useful for a teacher to have these views emerge and shared in class discussions (Askell-Williams & Lawson, 2005; Dillon, 1994; Sprod, 2001).

Table 3: Year 12 students' statements about what helps them to learn

ID	What can other people/ resources do to help you to learn?	How does this help you to learn?
1.	Preparation	An organized / well-structured lecture makes it easier to learn as everything comes in a logical easy to understand way.
	Enthusiastic delivery	Easier to concentrate and information is more easily remembered.
	Asking questions	Forces me to concentrate – if I get a wrong answer it sticks in my mind.

	Providing background / supporting notes	Easier to put things in perspective without the pressure of getting down all the information; really concentrate on understanding.
2.	No response	
3.	Make sure that their information is reliable and up to date	Being told the right story, not wrong information
	The lecturer has thought through the issues comprehensively	Get an in-depth idea of the issue, and so a better understanding
	Be visual and aural	More memorable
	Make the talk interesting and memorable	Helps you stay alerrt and remember what you are being told
	Make it relevant and relate it to the audience's world and lives	Engage their interest and help them to remember
	Use memory aids and mnemonic devices	Trigger your memory and help you not to forget
4.	The students can be quiet	I can concentrate
	The lecturer can talk interestingly	I don't get bored
	The lecturer can write stuff down	So it's more interesting and I can remember more
5.	Stay quiet	Able to devote attention to the lecturer
	The lecturer can ask questions and interact	Makes it more fun and interactive
6.	Have diagrams / pictures	Because having someone talk for ages is boring so it helps to have something to look at
	Keep class entertained not boring tone	Listening to a boring monotone voice is hard so its better if the person is enthused
7.	Take notes and share with other i.e. discuss them	Hearing what they say and then writing it down, you can comprehend it and compare
	Listen and take it in	Accepting what they say and really listening can add to understanding making it easier to help others understand when in discussion
	Teachers shouldn't talk in a boring monotonic voice	When a person speaks with passion, a person is more likely to take in what they are saying
8.	Talk to the class about	Let the students know what they

	the topic beforehand	are about to undertake and provide brief background / info etc
	Discuss the notes before, during and after lecture	Talk with students so that can display what they already know, and during important parts of the lecture discuss with students

	Read off PowerPoint/overhead	Students do not have to listen whilst writing all of the time; teacher can highlight and expand on specific points with diagrams etc
9.	Guide learning	Learn about what you need to know
	Ensure it will stick in the mind with some amusing observation	Information can be easily remembered and recalled
10.	Obtain a more learned opinion, i.e. teacher	Give facts and theories and background information.
	Generally, more important points are in handouts or on board	Makes it difficult to miss important facts and ensures you get the information you need
11.	Notes with bits to fill in as speaker talks	Don't stress about writing every word, but keep up by following and think and remember by writing some bits
	Speaker stating some things as questions; trying to keep you interested	It can be easy to tune out but if there are little things so it doesn't become monotonous, then it's easier to follow
	Repeat important things	Make them stick in my mind
12.	Handing out notes in lecture	I can read along with what's being said and not get so lost
	Summarising shortly at the end	Reiterate to myself that I have understood everything
	Have a visual presentation such as PowerPoint	I can read along with what's being said and not get so lost
13.	Concise, structured lesson	Learn only what's relevant
	Some anecdote about the teacher's lesson stays in your mind	You remember what has happened in the lesson, and then also, what was discussed

A sample of students' interview responses

The child-care participants spent part of their instructional time in class, and part on-the-job in a child-care centre. These students showed signs of integrating the theoretical and practical components of their training into their overall mental models of learning. For example, Table 4 contains a summary of the students' comments about the links between theory and practice.

Table 4: Child-care students' statements about integrating theory with practice

Arma	You see what's on paper in real life; think back to school – this is what we do; on the job and off the job is really important
Bella	CCC helps you understand what you've learnt in class; CCC give you an experience to try the things you've learnt in class; can't try things out in classroom; just taking teacher's word for it
Jay	Pretty close match; learn about things – it all goes into practice
Juli	Because we're at the CCC it's easier to understand what they're saying in lessons
Mary	CCC reminds me of what was in book & happened in class; conscious of what to do; do your theory – you think about it. Becomes a subconscious knowledge – do it automatically; if I hadn't done the theory, I wouldn't be as aware, wouldn't have remembered in the CCC; wider knowledge; CCC & class work together, CCC gives practical examples; practice, gets drilled into us as we're learning about it instead of after we've finished and half forgotten; identify with what's happening & bring it to class; in the CCC we're taught what to look out for in class; if I did all my work I'd have a better understanding; I'd be able to do CCC better, that's what the theory is for
Jess	When I put into practice what I've learnt in theory; gives me the information I need & the opportunity to put into practice
Lara	Putting what they tell you into practice
Ken	The books are designed to go with the training; the assignments are based on your experience; it's a great way to do it; it's easy if I'm writing from my own experience
Jen	On paper & in real life, same stuff, situations just come up, can't run to book; learn what CC is all about; in books; in real life; in the end theory & practice come together; real experience confirmed what is in the book; go through it properly and get it [know it] for good [properly] as it is written in book; learn what CC is all about; in books; in real life
Grace	Take the lessons from a book & put them into real life it can be difficult; not everything in CCC is text book scenario; don't find the time to incorporate textbook solutions into practice; you go along with it; put theory into practice; it's surprising how much you've learnt; from the classroom into the CCC
Cait	I guess because we've done um… occupational health and safety, you know, lectures and stuff, I'm taking that from the classroom into the centre with me

It can be seen from Table 4 that Bella and Jay say that what happens in the child-care centre helps them to understand what is learned in class, while Mary, Jess, Lara and Cait take the

lessons from class and put them into practice in the child-care centre. Ken explains how the competency books are designed to go with the practical experiences, and that he can write answers in the books from his experience. However, Grace cautions that often there is insufficient time to incorporate textbook solutions into practical application in the child-care centre.

Establishing links between theory and practice is a critical issue, not just for employment related training, but also whenever teachers intend that what happens in classrooms will have relevant application beyond the classroom walls. The comments of the child-care students suggest that these students possess knowledge that would provide many 'entry points' for further explicit teaching about theory-practice interactions.

Using students' prior knowledge as 'entry points' for teaching

We consider that eliciting the knowledge about learning held by our participants has been informative in two respects. Firstly, from a theoretical perspective, it provides the basis to propose that students' knowledge about learning is complex and multi-faceted. Secondly, from a practical perspective, students' knowledge presents a valuable resource that can be mined by teachers with a view to further developing students' mental models about learning.

Many of the participants in our studies appear to have only partially developed their literacy in the domain of learning. As is the case with their use of language or number or technology, students will be advantaged if they can, in Lemke's (2005) words, exploit the links between meanings and doings: links between what they identify as important in a situation and the actions they carry out to construct knowledge about that situation. Students need to be flexible users of the ways of the discipline of learning, so that they can be insightful critics of their own learning practices (Mathison, 1998). The less well-developed their knowledge of the ways of the domain of learning, the lower will be their capability to act critically as lifelong learners. This in turn will translate into a lower ability to construct knowledge in the students' subject-matter domains. And from a transactional perspective, if the quality of the interaction between the students' knowledge about learning and knowledge about subject-matter is limited by deficiencies in the former knowledge domain, then the students will be less able to generate better developed knowledge in both domains.

How does this translate into practical action for us as teachers?

Once again we turn to Mya. It can be seen that the relatively simple act of conducting an interview about learning with Mya can provide insight, for both teacher and student, into Mya's knowledge about learning. Such insight has the potential to provide "entry points" for Mya's teacher(s) to deliver instructional interventions about learning, such as readings and class discussions about focussing attention, activating prior knowledge, and generating meaning for the material to be learned. There is also potential for such an interview to stimulate Mya into self-reflection about her knowledge about learning, which can be supported by appropriate scaffolding, such as readings and conceptual frameworks.

Similarly, the flow chart of Sam's knowledge about self-regulation, viewed through the structure of Zimmerman's theory of self-regulatory stages, can provide a starting point for teachers and their students to investigate the nature and the structure of students' understandings of self-regulation. These starting points can be built upon in class discussions. Questions can also be raised for the teacher, such as whether the student shows signs of engaging in strategic planning, or of attributing the causes of successes to self-controlled efforts. Answers to such an analysis could also provide the entry points to teaching students about key ideas in learning, such as enhancing self-efficacy and attribution theories.

Coded statement trees and concept maps are economical means for making explicit to students and their teachers the structure of students' mental models (McKeown & Beck, 1990; White & Gunstone, 1992). The statement trees and concept maps can be viewed, compared, and used as starting points for discussions and reflective thinking about key issues in learning, such as the connections between various modes of instruction and student learning activity. In addition, statement trees and concept maps can provide evidence about students' knowledge growth. Collecting information about students' knowledge about learning does not need to tax the time available in tight classroom schedules. The responses we collected from students were mostly obtained in regular class lessons, providing not only the opportunity for individual student reflection at the point of collection, but also, a database of material that could guide teachers' planning of future instruction about learning. Our one-to-one interviews were more time intensive, but approached differently, say where students interview each other about learning, interviews could be transformed into a learning, as well as a data collection, exercise.

Conclusions

In this paper we argue that it is important for teachers to access good representations of their students' knowledge about learning in order to design and implement well-targeted instructional interventions that seek to enhance students' capabilities to transfer both their subject matter knowledge and their knowledge about learning to new settings.

Firstly, our analysis of students' interview transcripts using visual displays such as flow charts, trees, tables and concept maps, suggests that students' mental models are complex and multidimensional. Many theoretical constructs, such as approaches, goals, conceptions, self-efficacy, assessments of task difficulty and value, and so on are apparent in these representations. Furthermore, students possess, often in an implicit form, the beginnings of what could be developed into explicit instructional theories. We consider that, for the purposes of identifying students' learning needs in the domain of learning, it is insufficient to simply characterise any student as being, for example, a 'surface' or 'deep' learner (e.g. Knapper, 2001).

Secondly, characterisations of students' mental models of learning need to take account of students' finely attuned responses to situational affordances and constraints. If learning, and knowledge about learning, really are acquired in situation and applied in context, then we would predict a dynamic interplay between functionally available knowledge about learning and each specific learning context (Bandura, 2001). A transactional perspective is congruent with discussions of the inherent variability of thinking (Siegler, 1996), as genetic predispositions and environments together contribute to, and are part of, a developing system (Bjorklund & Pellegrini, 2004). In a discussion of children's thinking, Siegler (1996 p. 113) referred to a dynamic 'cognitive ecosystem', which evolves over time as strategies cooperate and compete with each other. The cooperation and competition between personal motivations, efficacies and situational affordances and constraints that emerged from our participants' accounts could also be described using Siegler's metaphor.

Using everyday pedagogical techniques such as discussions, reflective written responses, flow charts, statement trees and concept maps, classroom teachers are in a powerful position to elicit detailed information about their students' mental models of learning. This information can then be used as starting points for targeted instructional interventions designed to enhance the quality of students' knowledge about learning, thus preparing students to be more generative in their engagement with their various subject matters. We cannot assume that exposing students to schooling situations is a sufficient strategy to enable students to 'absorb' knowledge about how to maximise their learning opportunities. To omit explicit instruction about learning does a disservice to students who are attempting to master subject matter knowledge. The explicit development of all students' knowledge about learning across multiple contexts is critical.

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Appendix A: Overview of focus questions for written responses and interviews

Year of data collection	Focus Questions	Participant Group	Response Format
1999	What are the features of interesting class lessons?	Middle-school students	Extended written responses
2000	How does what you are doing help you to learn what you are meant to? Who an/or what helps you to learn? How do they/it help you to learn?	Primary, secondary, child-care, foundation and medical students	Short written responses and extended interviews
2001 & 2002	What happens in your university classes that help you to learn?	Teacher education (third year and final year) students	Short written responses.
2002	In what way does your earlier statement “X” help you to learn?	Teacher education (final year) students	Extended interviews
2004	In what way can your teacher use “X” to help you to learn? In what way can you use “X” to help you learn?	Secondary students	Extended written responses
2004	In what way can your teacher use “X” to help you learn? In what way can you use “X” to help you to learn?	Teacher education (second year) students	Extended written responses and extended interviews