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"Well the first thing I done was to ask my Mum to go on the internet"

A classroom based investigation into Year 8 students' knowledge about learning

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Students require knowledge that allows effective self-management of their learning. When students learn they use and construct knowledge in different domains. For example, they develop knowledge about subject-matter, knowledge about themselves and others, knowledge about their learning situations and knowledge about the learning process itself. This paper reports a classroom based investigation into interactions that occur between different knowledge domains. We conducted taped, in-class interviews about learning with a class of Year 8 students before, during and after their engagement with a self-selected independent investigation that ran during a whole school term. We used NUD*IST data analysis software to thematically code the students' statements. Certain themes were well represented, such as personal interest, planning and organising, and asking questions to gather information. Other themes were less well represented, such as metacognitive monitoring and higher order thinking about the gathered information. Students focussed upon the collection and presentation of gathered information, but some students did not appear to engage in thinking that allowed them to "go beyond the information given." More precise knowledge about the interactions between students' knowledge domains, such as between subject matter knowledge and learning process knowledge, will enable teachers and students to act more effectively during teaching and learning.

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Introduction

Students require knowledge that allows effective self-management of their learning. When students learn, they use and construct knowledge in different domains. For example, they develop knowledge about subject-matter, knowledge about themselves and others, knowledge about their learning situations and knowledge about the learning process itself. In this paper we describe a study where we talked to students about their learning while they were engaged with a classroom-based learning task. The broad approach of our research was to access students' verbal reports of their knowledge about learning whilst they were engaged with an authentic learning task. Our aim was to develop a better understanding of the interactions that occur between students' subject-matter knowledge and their knowledge of learning, including metacognitive and motivational knowledge. Detailed knowledge about these knowledge interactions will enable teachers and students to act more effectively during teaching and learning.

From a constructivist perspective, learners build knowledge by adding to, and modifying, what they already know. Therefore, instructional design should take account of the existing knowledge that students bring to instructional opportunities (Bransford, Brown, & Cocking, 2000). The importance of prior knowledge for facilitating the acquisition of new task knowledge in constructivist paradigms, and in expert performance in problem solving models, has become increasingly recognised (Chi & Glaser, 1988; Eisner, 2000; Mayer, Larkin, & Kadane, 1984; Posner, 1988; Reimann & Chi, 1989; Sternberg, 1999). Teachers are urged to elicit students' existing subject-matter conceptions (and misconceptions) prior to, and during, instruction. This instructional need is now well recognised in relation to seeking out students' prior knowledge about, say, maths (Ball & Bass, 2000) or history (McKeown & Beck, 1990) or science (Cobb, 1994).

The need to seek out students' existing knowledge in order to inform instructional designs links to the key premise that underpins our research, namely, that for good instructional design it is also crucial to take account of students' knowledge about learning. Research shows that students vary widely in knowledge that allows them to exert effective management of their learning (Hattie, Biggs, & Purdie, 1996; Kiewra, 2002; Winne, 1987; Winne & Marx, 1982). For example, research by Pressley, Van Etten, Yokoi, Freebern, and Van Meter (1998) demonstrated that students have knowledge of a range of strategies for studying, for coping with distractions and for adjusting to different lecturers' styles and course demands. Luyten, Lowyck and Tuerlinckx (2001) described students' perceptions about learning tasks, finding that these perceptions were significantly associated with students' planned and executed learning activities. In other papers, we have reported on students' knowledge of what helps their learning in general (Lawson & Askell-Williams, 2001) (Lawson & Askell-Williams, 2002) (Askell-Williams & Lawson, 2005a), on students' knowledge of how class discussions helps their learning (Askell-Williams & Lawson, 2005b), and on students' knowledge of how teacher questions can be used to assist both students' learning and teachers' pedagogical practices (Tran & Lawson, 2003).

The act of learning can be conceptualized as a problem solving activity, namely the problem of how to best go about learning any given subject matter. If learning is conceptualized as a problem solving activity, then students require good quality knowledge about learning and about themselves as learners, in order that such knowledge can interact in a generative way with their existing and developing subject–matter knowledge. For example, Hattie, Biggs and Purdie's (1996) meta-analysis of metacognitive strategy training suggested that interventions to increase the quality of students' metacognitve strategy knowledge improves learning task performance. Furthermore, students' knowledge of metacognitive processes forms an integral component of self-regulation of learning (Zimmerman, 2002). Effective self-regulatory activity depends upon the student having access to well-developed knowledge of what should be regulated, how regulation can be enacted and when it appropriate to do so. Research in the area of the structural organisation and elaboration of students' subject matter knowledge by Mintzes (2000), Pearsall (1997) and White (1992) demonstrated that cognitive organizational strategies improve students' understanding of content domains. And substantial works in areas of motivation, such as achievement goals (Pintrich, 2000), social goals (Urdan & Maehr, 1995), self-efficacy (Bandura, 2001), attributions (Weiner, 1985) (Graham, 1991), approaches to learning (Biggs, Kember, & Leung, 2001) and self-theories (Dweck, 1999) attest to the impact of students' self-beliefs and motivations for learning upon their engagement with learning opportunities.

Glaser (1984) argued that successful learning requires a good knowledge base:

> The strong assumption, then, is that problem solving, comprehension, and learning are based on knowledge, and that people continually try to understand and think about the new in terms of what they already know. (Glaser, 1984, p. 100)

Similarly, Reimann and Chi (1989) investigated problem solving from the perspective of the essential role that an expert problem-solver's knowledge base plays in achieving problem solving success:

> The last years have seen the development of a psychology of experts' behaviour that is based on a knowledge level analysis. This analysis in terms of experts' information processing has overcome the myth of experts' "intuitive" problem solving wizardry by demonstrating over and over again that expertise is essentially related to experience—that is, experience acquired within specific domains. Thus, we might say that all of us are potential, if not actual, experts in one domain or another. (Reimann & Chi, 1989, p. 161-162)

The research by Reimann and Chi, and Glasser, can be extrapolated to suggest that if learners are to engage successfully in the problem solving task that is learning, then learners will need knowledge in all of the knowledge domains that might contribute to thinking during problem solving for learning. For example, Mayer (1998) proposed that learners need knowledge in three domains, namely will (motivation), skill (cognitive strategies pertinent to the subject matter) and metaskill (metacognitive strategies). If each of these knowledge domains is important for learning, it seems reasonable to propose that that these knowledge domains would not stand as isolated silos of knowledge, but rather, that the various knowledge domains would act in reciprocal transaction to promote learning.

A program of research by Veenman & Elshout (Veenman & Elshout, 1999; Veenman, Elshoutt, & Meijer, 1997) has been directed towards identifying interactions between the different domains of students' knowledge, such as relations between students' intellectual ability, and cognitive and metacognitive skills. Veenman & Elshout (1999) hypothesised that metacognitive skillfulness for a particular task increases with the acquisition of expertise in that task, and that, in reverse, increased domain specific knowledge will have an increased impact upon metacognitive activity. Schraw (1998) also questioned how domain-general metacognitive knowledge is related to domain-specific knowledge (p. 116). He proposed that whereas cognitive skills are confined to specific subject-matter domains, metacognitive skills are more general, and thus are able to span multiple domains.

Research into the interaction between motivation and learning has a long history of investigation (e.g. Murphy & Alexander, 2000), however less is known about the area of interface between cognition about subject-matter knowledge and knowledge about learning (including metacognitive knowledge). Although there exists strong argument that knowledge about subject matter, and knowledge about learning, need to be taught and learned in conjunction (Perkins & Salomon, 1992), the nature of the interface between these different knowledge types is not well understood. Therefore, in this paper we investigate the nature of interactions that occur between different types of knowledge as students' engage with learning.

Conceptual framework

In the matrix representation in Table1 we bring together exemplars of subject-matter knowledge, metacognitive knowledge and motivational knowledge. Our purpose is to provide a conceptual structure to inform our investigation into the nature of the interfaces between these knowledge domains. The concepts of declarative knowledge, procedural knowledge, conditional knowledge and self-regulatory knowledge (Anderson, 2005) (Zimmerman, 2002) provide the organising principles for the rows of the matrix. The knowledge domains of subject-matter, metacognition and motivation (Brown, 1978; Chi, 1981; Mayer, 1998; Schraw, 1998) provide the organising principles for the columns of the matrix. To illustrate the nature of each cell entry, we have taken examples from the subject-matter of music, which we anticipate to be relatively accessible to a diverse range of readers.

Table 1: A conceptual representation of knowledge interactions

	A **Subject-matter knowledge**	A + B **Interaction**	B **Meta-cognitive knowledge**	B + C **Interaction**	C **Motivational knowledge**	A + C **Interaction**
Declarative knowledge	Knowing facts about the subject. e.g. The harmonic structure of that piece is tonic, dominant, subdominant and back to tonic.	e.g. I have a good memory for harmonic structures	Knowing about one's learning capacities e.g. I have a good memory	e.g. I like studying because I have a good memory	Knowing one's interests, self-efficacy and attributions e.g.I like studying	e.g. No matter how much I practice, I don't have the ability to develop absolute pitch (attribution).
Procedural knowledge	Knowing how to solve problems in the subject-matter domain e.g. The first letters of the stave mnemonics* are the letter names of the lines and spaces on the stave	e.g. Using stave mnemonics to facilitate reading notation	Knowing strategies for learning e.g. Using a mnemonic to learn things that are difficult to remember	e.g. Practising strategies such as mnemonics every day with the goal of improving	Knowing what actions are required to achieve one's goals e.g. Practising every day to achieve my goals	e.g. I practise stave mnemonics every day with the goal of improving notation reading
Conditional knowledge	Knowing when and where to use subject matter knowledge e.g. This particular stave mnemonic applies only to the lines of the treble stave	e.g. Correct my notation reading errors whilst practising, but ignore my errors while performing.	Knowing when and where to use strategies for learning e.g. I need to use my ears to identify my sight reading errors in order to know to correct them	e.g. Do I like practising every day so that I can play well at the concert?	Knowing where and when different motivations operate e.g. Sometimes I like doing things and sometimes I don't	e.g. Sometimes I feel like listening so as to correct my sight reading errors, and somethimes I can't be bothered as I just want to enjoy playing the music
Regulatory knowledge	Knowing about planning, monitoring and evaluating subject-matter knowledge e.g. That piece was played in the Romantic instead of the Baroque style	e.g. Do I know the defining features of the Baroque style?	Knowing about planning, monitoring and evaluating cognition e.g. Do I know this?	E.g. Can I be bothered learning about the history of music, or do I just want to play the piano?	Knowing about monitoring one's own motivations e.g. Am I getting satisfaction out of doing this?	e.g. Do I enjoy learning about the history of music? Will this knowledge help me to achieve my goal of playing well at the concert?

* such as Every Good Boy Deserves Fruit, to remember the notes written on the five lines of the treble stave

In columns A, B and C in Table 1 we categorise, for the purposes of analysis, different types of knowledge into the categories of subject-matter, metacognitive and motivational knowledge. In addition, in columns A +B, B + C and A+C we have provided examples of interactions between subject-matter, metacognitive and motivational knowledge.

It seems reasonable to propose that motivational knowledge is specifically tied to the target of the motivation, such as an interest in music, or maths, or science, (although Ainley (1998) argued for a domain general interest in learning that might equip students to take a cross-subject interest in school learning).

It may also be the case that metacognitive knowledge, although generally considered to be domain general, may in some cases specifically tied to subject-matter knowledge (Karmiloff-Smith, 1992), or at least more powerful or functional when tied to subject-matter knowledge. For example, Row 2: Column A provides the example of a stave mnemonic, which is problem solving heuristic specific to music, and Row 2: column B provides a general example of using a mnemonic to enhance learning. In Row 2: column A + B, a specific example of using a stave mnemonic to learn the notes on a stave is provided. It is clear that simply knowing a need to use a mnemonic is insufficient: Knowing which mnemonic to use is essential, and is dependent upon the subject-matter knowledge represented in Column A. It would be no use in the case of music to practice, for example, a mnemonic for learning the periodic table of elements. Furthermore, the entry in Row 3: Column A+ B, illustrates the need for subject-matter related conditional knowledge, where the stave mnemonic needs to be applied to the correct stave (for example, applying the treble stave mnemonic to the treble, not bass stave, as students often do) and also in appropriate situations (for example, while practising but not while performing). This is a self-evident example of the interaction between subject-matter knowledge, specific strategy knowledge and conditional knowledge, however, it does illustrate that it may be facile to consider one type of knowledge in the absence of the other.

The conceptual framework provided in Table 1 enables us to consider the implications of the interactions in columns A+B, B+C and A+C. One possibility, for example, is that students do not, in general, possess well-developed metacognitive knowledge, as seems apparent in Hattie, Bigg's & Purdie's (1996) meta-analysis. Another possibility is that students possess general metacognitive knowledge, but their subject-matter specific metacognitive knowledge is not so well-developed. General metacognitive knowledge that is not linked to relevant subject-matter knowledge may not be particularly powerful for generating good quality learning actions because the application of general metacognitive strategies may not be well-targeted to the subject-matter. The interaction between subject-matter knowledge and metacognitive knowledge is particularly illustrated in Table 1 at Row 4, Column B. A student may engage in reflection and ask him or herself "Do I know this?" However, the question doesn't make sense unless it relates to specific subject-matter knowledge. The question must be rephrased as "Do I know (for example, in this present case of music) the defining features of the Baroque styles?" Thus, possession of, or teaching of, a general self-questioning strategy might fail of it is not supported by sufficient subject-matter knowledge to support the asking of a relevant question. This is related to Chi and colleagues' (Chi, Bassok, Lewis, Reimann, & Glaser, 1989) findings, that some students in their study not only failed to understand the subject-matter they were studying, but did not recognise their failure to understand, thus preventing the students from moving on to engage in metacognitive self-correcting behaviours. This suggests that students may need a degree of subject-matter knowledge before they can fruitfully engage in a metacognitive self-regulatory behaviour such as self-questioning to monitor understanding. Anecdotal evidence from music suggests some support for this line of reasoning, whereby students know of the need to practice, and often devote many hours to practice, but such practice can sometimes entail practising errors to the point of perfection, rather than the metacognitively aware practice required for performance improvement.

However, the entries in Table 1 are illustrative of our conceptual framework, but at this stage still speculative. Hence, the broad research question addressed in this paper is "What is the nature of the interaction between students' subject-matter knowledge, metacognitive knowledge and motivational knowledge during learning?" To answer this question required us to gain access to students' thinking as they engaged with learning.

Method

Participants

A class of 29 Year 8 students at a metropolitan South Australian secondary school was approached to be included in this study. From that class, 27 students (14 boys; 13 girls) agreed to participate, with their parents'/caregivers' consent. Students' were 13 or 14 years old. They were predominantly of Caucasian heritage.

The lessons

In discussions with the students' class teacher, we identified a sequence of lessons that required students to engage in an authentic class-based learning task, namely, an independent investigation on a topic of the students' choice. This lesson sequence formed part of the class teacher's program that she had first used with Year 11 students as part of their SSABSA English Language and Communication Studies. The teacher

> *wanted students to consciously utilize their organizational and communication skills, all their cognitive and metacognitive knowledge of how to learn and how to communicate to create a project that interested and motivated them. This project would then hopefully strengthen their abilities and give them confidence to see that they are perfectly capable teachers of themselves and of each other. (Class teacher, Nov 2006)*

The independent investigation required students to produce the following three samples of evidence of their learning for assessment

1. a product--such as a magazine, a film, a model, or an event

2. a journal--documenting the processes undertaken to complete the work, showing what the student was doing and learning as the work progressed

3. a personal statement--explaining what the student did and how and why s/he did it, and which evaluates the student's efforts

Students were expected to consult with their classroom teacher as required during their independent investigation. The teacher required students to prepare a project proposal, including a method for completing their project, and to work through the project proposal with the teacher prior to beginning the project. Students could choose to work alone, in pairs or in small groups. The students undertook all sorts of assignments, such as teaching primary school children sport, organizing primary art classes, writing and illustrating books with younger children, organizing junior sporting competitions within their own school, finding out about careers, completing video and DVD fictions and documentaries, and making campaigns for advertising. Students made magazines, books about their friends, family histories and biographies, and undertook fund raising for charity. There were a series of 'How to…' guides. One boy created and performed in a clever political campaign. Some students prepared and taught one off or a number of lessons in their class. For example, one student taught the class a number of relaxation strategies over a term, and a young choreographer took some weeks to teach the class a simple dance. The scaffolding provided by the teacher included models and examples of previous projects:

> I talk the whole class through the nature of the assignment and processes for completing it. I identify specific examples of how to go about completing a study. And I suggest lots of ideas for projects and identify some of the steps kids have gone through in the past to complete their assignment. I have sometimes invited older students to talk to younger ones about how they went about their work. And I have kept examples of completed studies to show kids what others have done, though not always the best ones for it has been hard to get kids who were proud of their work to give it up, or it has been promised to others. (Class teacher, Nov 2006)

As part of their end-of-year reflection on their Year 8 studies, the students could also discuss the independent investigation in a letter and an interview focusing on how they went about their learning and what they discovered about their strengths and weaknesses as learners. Many students took this opportunity to further reflect upon their learning.

The Independent investigation met our research objectives in the following ways

- The free choice nature of the investigation suggested that students would select a topic of personal interest to investigate, thus ensuring that most students would be engaged in the activity.

- The open ended nature of the task provided a range of possible response options, and therefore a potentially broad range of student knowledge for us to access.

- The learning objective of developing students' self-regulated learning, and the activities that students would engage with to achieve that objective, were considered to be consistent with our intention to investigate students' knowledge about learning.

Instrumentation

We collected data about students' knowledge about learning in three ways, namely questionnaire, in-class interviews and written learning statements, as follows:

A "Thinking about your learning" Questionnaire

Given that the proposed learning outcome of the Independent Investigation was to develop students' self-regulatory learning skills, we were cued to Zimmerman's (1989; 2002) framework of self-regulation to provide the theoretical background to construct a questionnaire to investigate students' knowledge about their own learning. Zimmerman's three main phases (forethought, performance control and self-reflection) and subcategories of self-regulatory knowledge that we employed to generate individual questionnaire items are listed in Table 2.

Table 2: Framework for self-regulation used to construct a "thinking about your thinking" questionnaire (after Zimmerman, 1989, 2002)

Forethought Phase	Performance Phase	Self-reflection Phase
Task analysis	**Self-control**	**Self-judgement**
Goal setting	Attention focussing	Self-evaluation
Strategic Planning	Self instruction	Causal Attributions
	Imagery	
	Task strategies	
Self-motivation beliefs	**Self Observation**	**Self-reaction**
Self-efficacy	Self-recording	Self-satisfaction/affect
Outcome expectations	Self-observation	Adaptivity/defensiveness
Goal orientation		
Intrinsic Interest/value		

Within each subcategory, we referred to existing questionnaires in that domain (if available), such as self-efficacy (Bandura, 1997; 2001), achievement goals (Pintrich, 2000; Pintrich & DeGroot, 1990), approaches to learning (Biggs, 1987; Biggs et al., 2001) , metacognitive knowledge and control (Schraw, 1998) self-theories (Dweck, 1999), and attributional statements (Graham, 1991). We created, adopted and adapted questionnaire items so that they specifically referred to our participants' learning task, namely, the independent investigation. Questionnaire items required either short written responses or responses on a 5 point Likert scale. Sample items included

Question 1.   How will doing this investigation help you to learn? (short answer response)

Question 5. What strategies did you learn from the last time you did an independent project that will help you for this project? (short answer response)

Question 9. 2 I am making a plan for how I would go about doing my project (Likert scale response)

In-class Interviews

Drawing from the research tradition of collecting verbal protocols (Ericsson & Simon, 1993), we asked students to talk about their thoughts and actions whilst they were engaged in typical class-based learning activities. We composed a focused interview protocol that asked students to tell us about their learning activities.

The interview questions were

1. Tell me about your independent investigation

2. What things have you done so far in the investigation

    Prompts (if required)

        Have you talked to anyone about it?

        Have you looked at anything?

        Have you read anything about it?

        Have you written anything?

3. How is what you have done so far helping you to learn about the topic?

4. What are you doing to make sure that you are learning really well?

5. Have you done any other things in the past week that have helped you to learn really well?

Personal Learning Statement

One of the assessment tasks for the independent investigation was a personal statement that was intended to be each student's reflective account of their learning progress. These statements provided an additional source of data about students' reflective thinking about their learning.

Data collection Procedure

Students worked on their independent investigations over the course of 10 weeks. In lesson one, the class teacher introduced the students to the goals and proposed outcomes of the independent investigation. The questionnaire "thinking about your learning" was administered in lesson 2, prior to the students commencing work on their independent investigation.

We attended the class lessons and interviewed students as they worked on their independent investigations. These interviews were conducted over a period of approximately 10 weeks. Each student was interviewed at least once. Eight students, who were identified by their class teacher as being high (4) or low (4) achievers, were targeted for repeated interviews, and were interviewed up to four (according to school attendance) occasions each. Interviews were audio-taped and transcribed. We collected copies of students' learning statements at the end of the 10 week lesson sequence.

Results

Questionnaire Responses

Table 3 contains the class mean scores for each of the questionnaire items. Students were generally positive (more than the mid-point of the Likert scale 3) about their self-regulatory knowledge and skills.

Relatively high class mean scores (more than 4 on the Likert scale) occurred for the *forethought* items, 3: *I am capable* and 4: *I want to really understand,* and the *performance control* items 14: *I go back over it again*, 16: *I know when I do understand*, and 19: *I put in the effort.*

The relatively low response of 2.8 for the *performance control* item 9: *I ask myself questions,* suggests that students do not know about, or if they do know about it, do not use, this valuable metacognitive strategy for monitoring understanding as frequently as educators might wish.

Profiling students' questionnaire responses

To refine our understanding of students' questionnaire responses beyond the relatively coarse analysis provided by class mean scores, we created profiles of the responses from the eight students identified by their class teacher as being at relatively high or low achievement levels. The student profiles are displayed in Figure 1, where individual patterns of variation can be noted between the students. The four profiles in the top half of the page are from students identified by their class teacher as being relatively low achieving students in the class. The four profiles in the bottom half of the page are from students identified by their class teacher as being relatively high achieving students in the class. Although the peaks and troughs of the profiles are specific to each student, it can be observed that generally, the higher achieving students' profiles sit higher on the Likert scale (scores 1 to 5). In particular, whereas the higher achieving students have multiple nominations of score 5 on the Likert scale, the lower achieving students have only one to three nominations of score 5 on the Likert scale. Interestingly, the high and low achieving students also showed some similarities in response patterns to two items, namely, item 8, (form mental pictures) which tended to be low, and item 20 (the work to be set at the wrong level for me), which tended to be high, relative to each students' other scores. The point to be taken from these profiles is that students enter each teaching learning transaction with different degrees of knowledge of learning, or what might be termed learning capital. The degree of development of this learning capital will mediate their ability to engage with learning opportunities.

Table 3: Class mean scores to questionnaire items

Forethought

	Class mean (max=5)
1. I understand what I am required to do	3.7
2. I am making plan for how I would go about doing my project	3.6
3. I feel that I am capable of learning about my subject	4
4. I want to really understand my subject	4
5. I really only need to learn about the subject enough to get me through (reverse item)	2.4
6. I am interested in learning about the subject	3.7

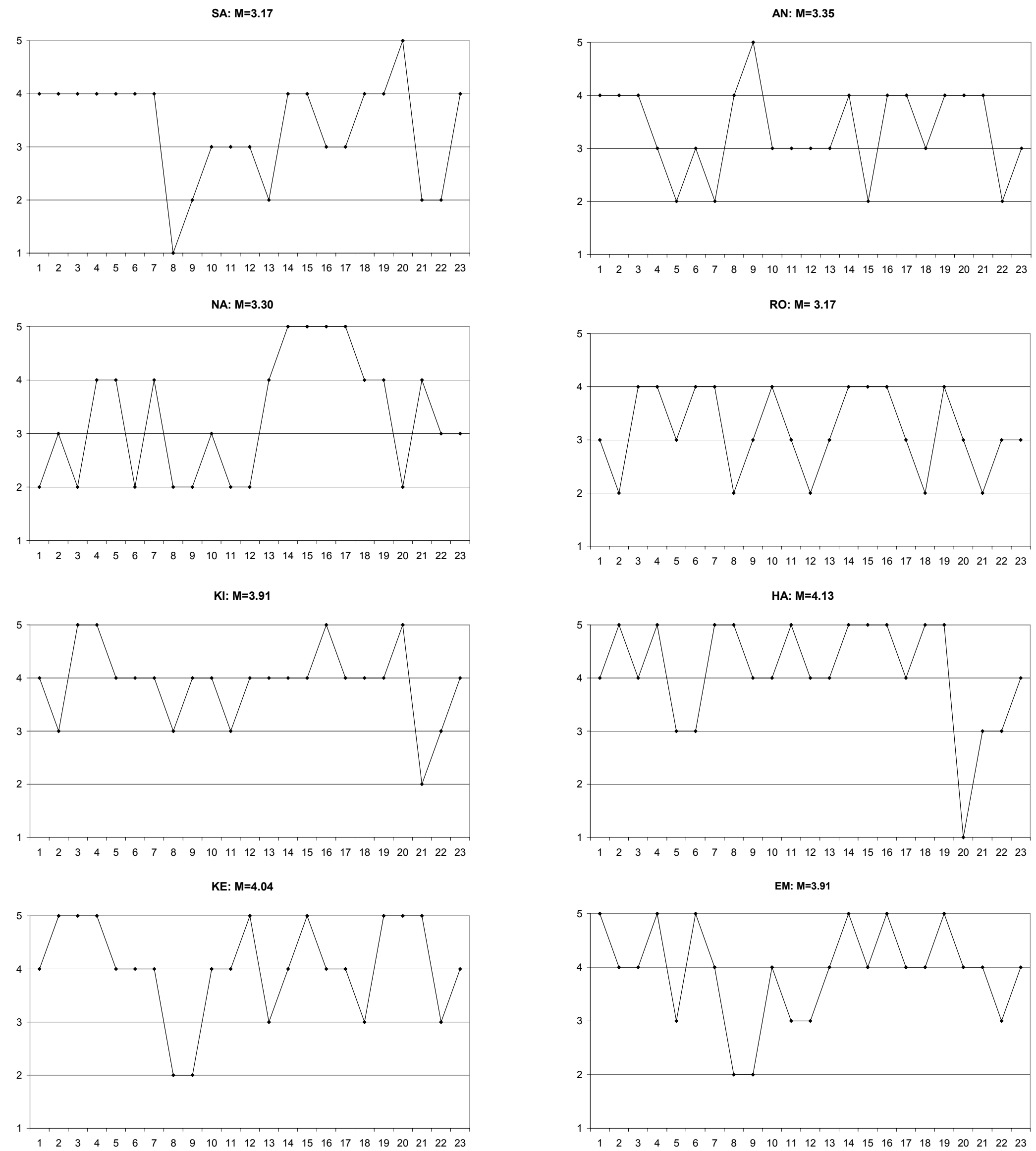
Performance control

	Class mean
7. I try to concentrate my attention to focus on the subject	3.7
8. I form mental pictures in my mind to help me to understand the subject	3.1
9. I ask myself questions about the subject to see if I understood it.	2.8
10. I try to fit new information into what I already know about the subject	3.7
11. I make connections between different pieces of information, to try to create a bigger picture	3.3
12. I have ways of making the important information stand out in my mind	3.1
13. I keep checking my thinking, to see if I am understanding the subject	3.2
14. When I don't understand something, I go back over it again	4.1
15. When I don't understand something, I ask a question about it	3.7
16. I know when I do understand something	4.2
17. I have a reasonable idea of how well I understand the subject	3.8
18. I have a reasonable idea of how well I would do if I had to take a test	3.5
19. I will be able to understand the subject if I put in the effort	4.3
20. I think the project is set at the wrong level for me (too hard or too easy)	2.3

Reflection

	Class mean
21. I have personal feelings about this subject	3
22. I expect that what I am learning will change the way I used to think about something	2.9
23. I can do independent investigations successfully	3.5

Figure 1: Eight student questionnaire response profiles



Questionnaire items (short names)

1 understand what's required
2 making a plan
3 I am capable
4 understand my subject
5 get me through
6 I am interested
7 concentrate my attention
8 form mental pictures
9 ask myself questions
10 fit new information
11 make connections
12 make information stand out
13 checking my thinking
14 go back over it
15 ask a question
16 I know when I do understand
17 idea of how well I understand
18 if I had to take a test
19 put in the effort
20 set at the wrong level
21 have personal feelings
22 change the way I used to think
23 can do independent investigations

Interviews

All of the in-class interviews were transcribed and formatted into individual text 'units of meaning' suitable for entry into *N6* (formerly NUD*IST) (QSR) software. Units of meaning could be a single word, a phrase or a sentence that contained a single idea. We used the capabilities of *N6* to categorise students' interview responses according to the conceptual framework introduced in Table 1. In the discussion that follows, we present examples of students' interview responses. In addition, we present a detailed analysis of one student's (D.A.) responses, represented in Table 3.

Knowledge gathering and Knowledge Transforming

Overall, students were well versed in activities required to collect information for an independent investigation. Most students talked with others and, across the group, these other people included teachers, fellow students, parents, people in local business or service providers, friends and people in the community. Knowledge gathering from reading and from the internet were also frequent activities. Many students recognized that parents and teachers were sources of help and information. Eighteen of the 27 students used the internet as an information source.

The conceptual model proposed in Table 1 suggests that powerful learning, in the sense that students generate new associations that cause them to elaborate their mental models, occurs at the interfaces of knowledge about subject matter, metacognition and motivation. This interpretation was represented in participants' transcripts by statements that could be classified into two major themes, namely, "Knowledge gathering activity" and "Knowledge transforming activity". These themes, and the sub-categories represented in each theme, are displayed in Figures 2 and 3. It can be seen that the themes identified in "Knowledge gathering activity", such as "repeating," "copy out" and "ask someone" indicate that the students search out information, but these statements do not indicate that the students cognitively act upon the information in a substantial way.

J.A.: *um - repeating things - usually if you're continuously repeating things you remember it quickly cos it sticks in your head*

E.M.: *re-read it all and I typed it up so I was reading everything so I learnt most of it*

S.A.: *um, the …um, the interview we sent to the zoo, what questions we asked and that ... to find out information that we don't know… really*

R.O.: *I got information off the net and then copied it - didn't copy it word for word, but mixed it up a bit.*

S.A.: *I just changed the words*

Repeating or just changing the words may be precursor strategies for learning, but they are, on their own, not very powerful because they do not involve the elaboration of knowledge. Simple repetition does not guarantee that links will be formed between new and existing knowledge or that more complex patterns of organization of knowledge will ensue.

In contrast, the activities identified in "Knowledge transformation activity" such as "categorization," "make it understandable" and "teach other people," do require students to make judgments about the subject matter content and to make metacognitive decisions about the most appropriate actions to take on that subject matter, such as determining interest and relevance, assessing one's level of understanding, experimenting, and reflecting.

L.I.: *I reckon that why they put schools {subjects} in lessons, so that you don't just go into one massive lesson on and on so everything is jumping around but the put it into separate departments; so you have departments in your brain.*

K.I.: *With all the information it helped us to put it into categories…it's a good way to explain, to put into main headings*

R.A.: *What I do to learn, is probably teaching other people … like I've explained it. Cos when my Grandad explained it to me, I explained it to him, and that way I go "tell me more about that" when he read out the names and who they were related to, I wrote them down and go, "so this person is related to this person", he goes, "yep" - so that way I got it.*

T.I.: Um, I'm investigating things deeper than like just looking up information and reading it a few times. Like, just see if there's an extra link in the text like I'd just click on it to see what that part says.

H.A.: Yeah - In books, I - imagine a word, like what it actually looks like & stuff...Like, if I read I book, I can actually see what the person looks like, the actual place they are in, where I haven't seen the place before I can get really good perspective of it in my mind…Well, using more perspective, like - looks like, your perspective so you can give it more detail. More detail of the place that you're reading.

These statements indicate that these Year 8 students made quite sophisticated metacognitive statements about their learning activities. In addition, these learning acts indicate an interaction between each student's knowledge of the subject matter and his or her metacognitive knowledge about how to act on that subject matter. These interactions could be categorised in the A + B column of our conceptual framework detailed in Table 1.

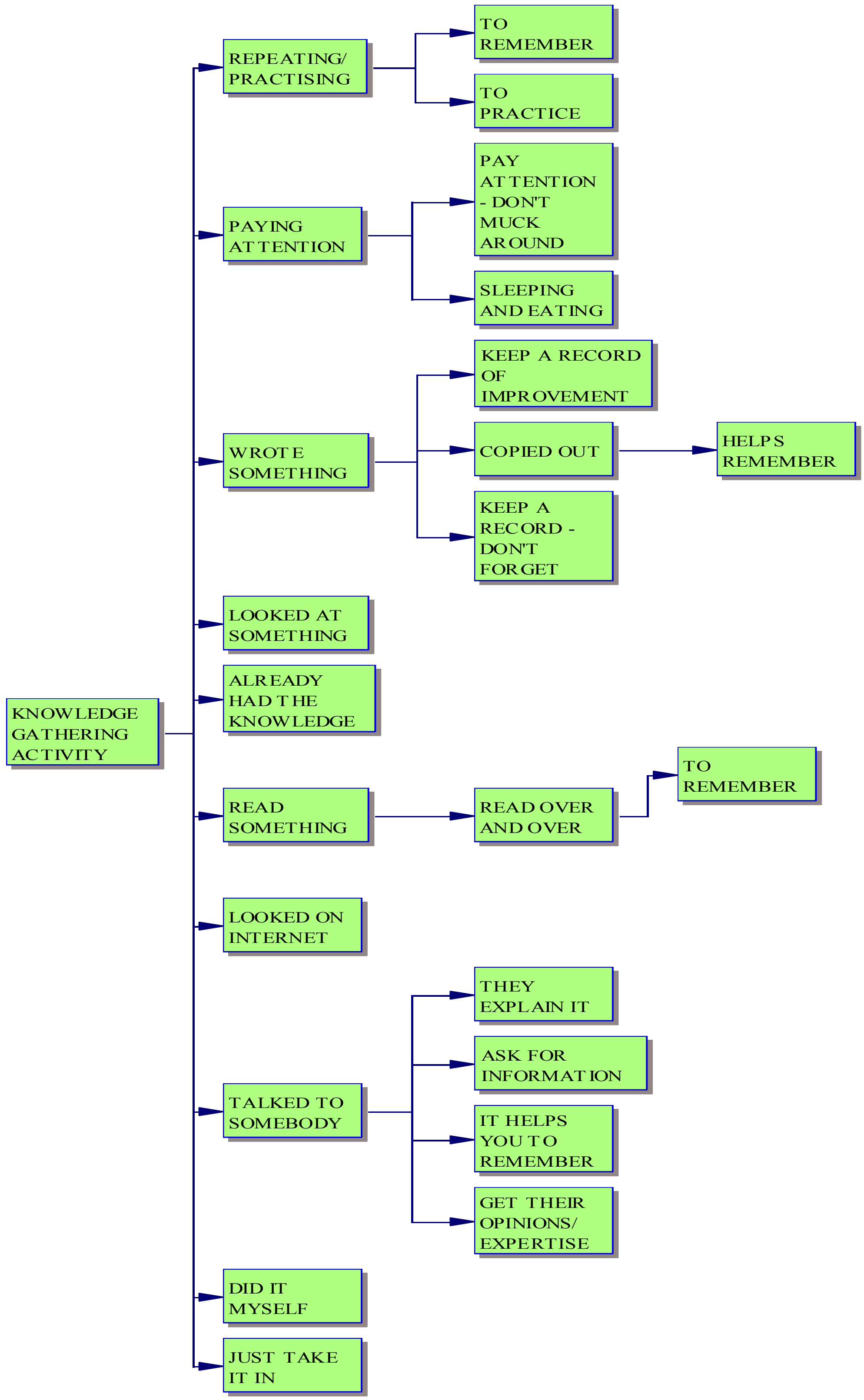


Figure 2: Categories for coding "Knowledge Transformation" statements from participants' transcripts

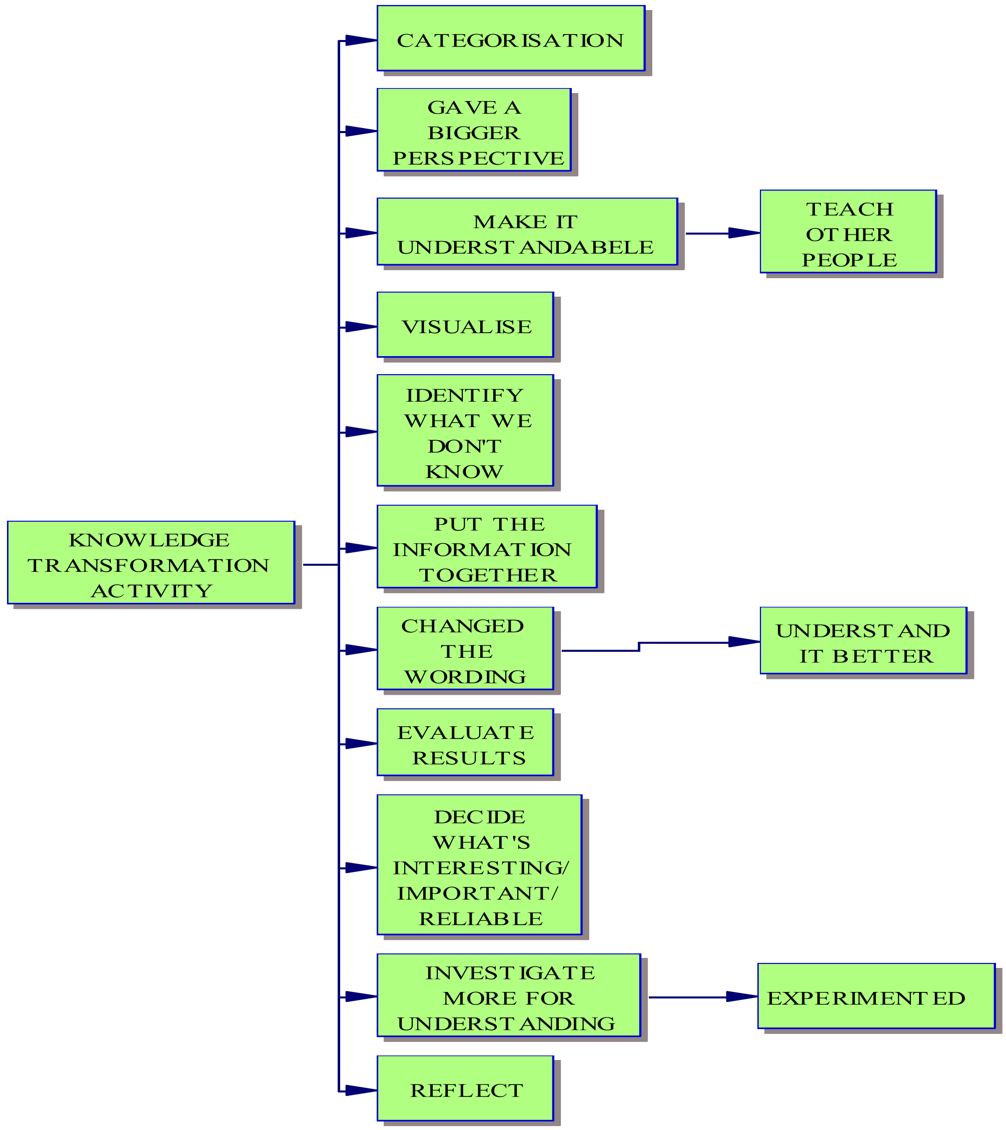


Figure 3: Categories for coding "Knowledge Transformation" statements from participants' transcripts

All of the Year 8 participants discussed knowledge gathering activities. Sixteen of the 27 participants discussed knowledge transformation activities. This frequency count, derived from the detailed thematic coding of students' responses using NVivo, is of particular interest for instructional designers. Certainly, gathering information is a first stage of a research enquiry. However, if a proportion of students do not progress past data collection to data analysis, elaboration, evaluation and interpretation, the question is raised of whether a self-directed independent investigation will contribute to construction of powerful knowledge by these students.

Two implications of this finding are raised by the conceptual framework detailed in this paper. The first is that the subject-matter might be conceived in such a way that it does not provoke substantial cognitive and metacognitive action. Mayer (2004) warned against the possibility that students might experience limited cognitive growth during *unguided* discovery learning.

The second possibility is that some students may lack sufficiently well-developed cognitive and metacognitive strategies to generate more powerful interactions with their chosen subject-matters. Such students are likely to benefit from having access to the sophisticated knowledge transforming strategies reported by many students in this class. This knowledge can be made explicit in class discussions, triggered by a question such as "How did you do that?"

A dominant concern: Time management

A major objective of participants' independent research project was for students to develop skills of self-regulated learning. One major aspect of self-regulation in a school environment is time management: Students' concerns with time management appeared repeatedly in the interview transcripts and personal statements collected for this study. Students spoke and wrote at length about the need to manage their time to "get the work done."

N.A.: *Um - I find it easier if I know how much time I've got, so then I can set out my work so that I get it all done by the due date.*

E.M.: *But I tried to spread it out evenly this time, I tried to follow the timeline, I did lots at the start, then not much in the middle, but I've done lots at the end.*

H.A.: *yeah like take time - coz we set out before that like a time line - so we had to fit everything to the time line so we keep in order….good organization skills - so like if we didn't keep a time line we might go over time then we might not hand it up on time.*

Students' concern with time management appeared at all of the phases of self-regulation documented in Zimmerman's framework (2002).

An in-depth analysis of one student's interview transcript

In this section we discuss an analysis of the responses of one student, D.A., in order to illustrate examples of knowledge transformation and elaboration. We lay the conceptual framework of knowledge interactions introduced in Table 1 over the contents of D.A.'s transcript in order to create the representation displayed in Table 3.

From Table 3, it can be seen that D.A. used the internet as an information resource. He began by asking his mum to go on the internet. He then went further. He made judgments about interest and relevance in the subject domain. Next, he translated the information for his own understanding, and then he adopted the perspective of a younger child, and translated the information again. He evaluated the difficulty of the task, and monitored his progress towards completion.

D.A.'s account indicates that he engaged in complex cognition. Note that this complex cognition is categorised in the 'interaction' columns of Table 3. In other words, metacognitive judgements about interest and relevance, were made in response to particular subject-matter content. If we consider a comparison between the entries in Row 2: Column A + C, and Row 2: Column B, the former strategy of making a judgment about what was 'interesting' on a web site is arguably a more powerful learning strategy than asking mum to go on the internet (although the later may be more expeditious in a school environment).

Certainly D.A. demonstrated general learning strategies, such as the extracts in Row 3: Column B, where he "goes back over' a text until he understands it. This problem solving heuristic (Perkins & Salomon, 1992) develops into the more powerful 'mindful exploration' that D.A. undertook when making decisions about items of relevance to be translated from a web page to an independent research project of writing for young children, such as in Row 3: Column A+B. Similarly, making decisions about translating difficult information into words that younger children would understand (Row 4: Column A + B) required D.A. to draw from knowledge of subject matter, knowledge of the reading capabilities of his intended audience, and metacognitive knowledge to plan and monitor his writing for that audience.

Table 3: D. A.'s interview organised according to the conceptual framework

		A Subject-matter knowledge	A + B Interaction	B Meta-cognitive knowledge	B + C Interaction	C Motivational knowledge	A+C Interaction
1	**Declarative knowledge**	Knowing facts about the subject. *There is the procedure of cloning - or nuclear transplantation*		Knowing about one's learning capacities *Well, I usually learn well when I'm not tired*		Knowing one's interests, self-efficacy and attributions	
2	**Procedural knowledge**	Knowing how to solve problems in the subject-matter domain	*I just looked at all the cloning websites and I downloaded a couple of pages.*	Knowing strategies for learning *Well the first thing I done was to ask my mum to go on the internet*		Knowing what actions are required to achieve one's goals	*And find some interesting web sites that could have information about cloning and GE*
3	**Conditional knowledge**	Knowing when and where to use subject matter knowledge	*Then I like looked at all the relevant information, I copied that down, then I had to try and write it into my own words*	Knowing when and where to use strategies for learning *If it's a written word you can keep going back over it again & again until you totally understand it*	*Sometimes there are things in your mind that get you side tracked, like what 's on TV tonight, and you think about it instead of the work you're meant to be doing*	Knowing where and when different motivations operate	
4	**Regulatory knowledge**	Knowing about planning, monitoring and evaluating subject-matter knowledge *Well I had the basic information I needed, but then there was the more indepth stuff, but how was the cloning procedure developed. And how difficult it was to try & clone a sheep.*	*Like I understand the cloning procedure...Then I had to try and write it into words that younger children would understand. Which I found difficult, but I've just about done….I'm not really sure how I'm learning, cos basically I didn't know much about genetic engineering anyway*	Knowing about planning, monitoring and evaluating cognition		Knowing about monitoring one's own motivations	

Summary and Implications for practice

In this paper we have reported a classroom based investigation into students' knowledge about their learning. Certain themes of knowledge were well represented in participants' accounts, such as personal interest, planning and organising, and asking questions to gather information. Students engaged in self-reflection about their learning, with much of this reflective activity being concerned with time management. The existence of this knowledge about learning, and the evidence of its use in our investigation, is noteworthy. Students use such knowledge in their class activities. Such knowledge can become the subject of discussion in classrooms, so that knowledge about learning can be developed, just like knowledge in other domains.

Our analysis indicated that many students did use knowledge transforming strategies that allowed them to "go beyond the information given" (Bruner, 1996). Some students showed less evidence of such knowledge transformation. The implication for practice of our analysis of the students' protocols is that some students may need explicit instruction in the application of cognitive and metacognitive strategies.

In the final section of this paper we employed a conceptual framework, of interactions between types of knowledge, to undertake a case-study analysis of the interview transcript of one student. This case-study analysis indicated that much of the student's thinking about his learning relied upon knowledge simultaneously drawn from more than one domain, involving interactions between subject-matter and metacognitive knowledge, and interactions between motivational and metacognitive knowledge. The implication for practice that flows from this analysis is that instruction in motivational dispositions, and metacognitive or cognitive actions, will be more powerful if it is integrated with subject matter knowledge. The increase in cognitive power will be associated with greater elaboration of the knowledge being gathered. There is a direct relationship between this implication and the first implication suggested in the previous paragraph. That is, motivation, cognition and metacognition operate in interaction, and thus must be jointly addressed in instructional designs.

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