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Scaffolding cognitive and metacognitive strategy instruction in regular class lessons

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Abstract

The quality of teachers' knowledge about how people learn influences students' learning outcomes. Similarly, the quality of students' knowledge about how they learn influences their engagement in self-regulated learning and consequently, their learning achievement. There is a gap between research findings that support these two premises and teaching-learning practices in classrooms. In this paper we describe attempts to reduce this gap. In Study 1 we surveyed early adolescent students' cognitive and metacognitive strategy use and demonstrated that students' cognitive and metacognitive strategy knowledge has substantial room for improvement. In Studies 2 and 3 we collaborated with teachers to embed explicit cognitive and metacognitive strategy instruction, using learning protocols, into regular class lessons. Studies 2 and 3 showed that the learning protocols slipped readily into teachers' typical lesson designs, scaffolded teachers' delivery of strategy instruction, and scaffolded some students' acquisition of strategy knowledge, although progress was sometimes slow. Recommendations are presented for supporting teachers and students to engage with cognitive and metacognitive strategy instruction.

Keywords: theory-practice gap; teacher knowledge; cognitive strategies; metacognitive strategies; learning protocols

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It is clear from research evidence that the quality of teachers' knowledge/beliefs, intentions, and plans with respect to how people learn influences teachers' teaching actions (Kerr, 1981; Lawson, Askell-Williams, & Murray-Harvey, 2009), and that those teaching actions directly influence students' learning outcomes (Bereiter & Scardamalia, 1989; Hattie, 2009; OECD, 2005; Rowe, 2002). Furthermore, the quality of students' knowledge about how they learn influences their engagement with learning, and consequently, their learning achievements (Bandura, 2001; Schraw, 1998; Schraw & Dennison, 1994; Schunk & Zimmerman, 1989; Weinstein & Mayer, 1986). However, as Hattie (2009 p. 3) asked, "Why does [this] bounty of research have so little impact?" We see that this lack of impact is associated with a gap between research findings and their use to inform teaching and learning practices (Bransford, Brown, & Cocking, 2000; Hattie, 2009). In this paper we report three studies that attempt to reduce this theory-practice gap, and show that research findings about strategies for good quality teaching and learning can have an impact on classroom practices.

Teachers' knowledge about how people learn

Teachers exert a direct impact upon student learning. Rowe (2002) and the OECD (2005) have reported that students of the most effective teachers have learning gains four times greater than students of the least effective teachers, that these effects accumulate over time, and that the single most important school-based variable of influence for student performance is teacher quality.

The knowledge-base that teachers can call upon to exert this influence includes components such as content knowledge and pedagogical content knowledge in subject-matter domains such as mathematics or music (Shulman, 1986a; 1986b;

1987; Grossman, 1995; 1995). It also includes content knowledge and pedagogical content knowledge about cognitive and metacognitive strategies for learning (Kiewra, 2002; Schraw, 1998).

However, there is evidence that many teachers do not begin their careers with strong knowledge about strategies for learning. For example, Woolfolk-Hoy and Tschannen-Moran (1999) worried that their student-teacher participants,

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

Similar findings were reported by Askell-Williams, Lawson and Tran (2007) who asked teacher-education students, “What happens in your university classes that helps you to learn?” Although the students’ responses included a range of learning strategies such as repetition, bouncing-off ideas, and help-seeking, some of these prospective teachers could not provide *any* detail about their learning processes. If teachers do not have well-developed knowledge about how to learn, it is unlikely that they will be able to lead their own students to develop knowledge about cognitive and metacognitive strategies for learning.

One reason for teachers’ lack of attention to learning itself as a subject-matter category might include their own lack of appreciation of the functional value of learning strategies (Kiewra, 2002). For example, McLeod (2008) found that the history teachers in her study rarely read educational psychology research reports, while Bransford et al. (2000) argued that many teachers feel that educational research has been largely irrelevant to their work. It is also possible that some teachers, in confusing constructivist theories of learning with theories of teaching, overlook the need for explicitly teaching students about cognitive and metacognitive strategies (Bransford et al., 2000; Gough, 1997; Tobin, Tippins, & Gallard, 1994). Teachers might also lack time to consider research reports amidst their other concerns such as behaviour management and testing schedules (Bransford et al., 2000; Cannon, 2006; Nuthall, 2004). Although there are good reasons why teachers may not systematically access and apply findings from research on learning (Joram, 2007), such a situation can lead teachers to continue to use less effective practices and neglect more useful ones (Bransford et al., 2000; Rohrer & Pashler, 2010).

In considering reasons for the research to practice gap, Dignath and Büttner (2008) noted an additional explanation, namely, that little information about how to *support teachers' practices* has followed from research findings that cognitive and metacognitive regulation leads to better learning outcomes. Without such teacher support, it is unlikely that there will be a major change in the impact of very useful research. If there is no change in the quality of teachers' knowledge about learning, then we see little prospect of change in the quality of students' knowledge about cognitive and metacognitive strategies for learning (Hugener et al., 2009; Kerr, 1981; Kiewra, 2002; Lawson et al., 2009).

Students' knowledge about how to learn

Alexander and colleagues (Alexander, 2005; Alexander, Graham, & Harris, 1998; Alexander, Jetton, & Kulikowich, 1995; Alexander & Judy, 1988) presented a series of papers arguing that students need to develop good quality domain knowledge, as well as strategic knowledge, in the subject-matter areas. Whereas this need for good quality knowledge is relatively easy to recognise in traditional content areas such as mathematics or music, the domain of cognitive and metacognitive knowledge about *how to learn* seems less explicitly recognised. A key premise of the current paper is that when students engage with learning, say in mathematics, they must use prior knowledge and expertise from at least two domains; the subject-matter domain, and the domain of knowledge about how to go about learning (Winne, 1987; Winne & Butler, 1994; Winne & Hadwin, 1998). However, students' knowledge about effective management of their own learning varies widely (Hattie, Biggs, & Purdie, 1996; Kiewra, 2002). In particular, low achieving learners can show substantial deficits of cognition, metacognition and motivation, and that "interaction between these component deficiencies compound difficulties" (Pressley, 1995 p. 5).

The range of student knowledge about how to go about learning has been documented in quite different contexts. For example, Pressley, Van Etten, Yokoi, Freebern, and Van Meter (1998) investigated students' knowledge about strategies for studying, for coping with distractions, and for adjusting to different lecturers' styles and course demands, finding that students' capabilities in these areas varied widely, and disconcertingly, in some instances. Luyten, Lowyck and Tuerlinckx (2001) found that variation in students' perceptions about learning tasks were significantly associated with students' planned and executed learning activities. Studies by Askell-Williams and Lawson have shown substantial variations in students' knowledge about such topics as, what helps their learning in general (Askell-Williams & Lawson, 2005a; Lawson & Askell-Williams, 2001, 2002), how class discussions help their learning (Askell-Williams & Lawson, 2005b), instructional metacognition (Askell-Williams, Lawson, & Murray-Harvey, 2007), and how teachers' pedagogical questions can be used to assist both students' learning and teachers' instructional practices (Tran & Lawson, 2007).

To address the development of students' knowledge about how to learn, an increasing body of evidence points to the efficacy of explicitly teaching strategies for cognitive elaboration of subject-matter and for metacognitive regulation (Mevarech & Amrany, 2008; Veenman, van Hout-Wolters, & Afflerbach, 2006; Zohar & David, 2008). Indeed, over the past five decades, the research literature has detailed many successful cognitive and metacognitive instructional interventions, including advance organisers (Ausubel, 1960), metacognitive evaluation matrices (Schraw & Dennison, 1994), worked examples (Sweller, 2006), concept mapping and other diagrammatic supports (Novak, 1990), and self-reflective learning protocols (Berthold, Nückles, & Renkl, 2007; Nückles, Hübner, & Renkl, 2009).

Hattie, Biggs and Purdie's (1996) early meta-analyses, the meta-analysis by Dignath and Büttner (2008), and Hattie's (2009) recent synthesis of over 800 meta-analyses, provide substantial support for the strong relationship between cognitive and metacognitive instructional interventions and improved learning outcomes for students. However, the up-take of cognitive and metacognitive strategies has been less than optimal in many classrooms (Bransford et al., 2000; Hattie, 2009). And so, Weinstein and Mayer's (1986 p. 744) question continues to be relevant: "What can we do to help teachers incorporate learning-to-learn activities into their classroom teaching?" The current paper reports three studies designed to address this question. The first was a broad scale questionnaire about students' reported use, in regular class lessons, of cognitive and metacognitive strategies. The next two studies investigated the in-class use of learning protocols designed to scaffold the development of students' cognitive and metacognitive strategies.

Study 1: A survey in three secondary schools in 2007

We have argued that research-based knowledge about the value of good quality cognitive and metacognitive strategies has achieved limited transfer to classrooms.

One outcome of a lack of connection between research and classrooms is that the precise nature of students' knowledge about their cognitive and metacognitive skills during their everyday engagement with typical class lessons is not well documented (Cook-Sather, 2002). Karmiloff-Smith (1992) argued that for optimal use of knowledge, the knowledge must at some point be made explicit and able to be discussed, used and refined. If knowledge, such as strategy knowledge, is not available to be inspected, refined, and purposefully selected for use according to contextual needs, then that knowledge will not be powerful for directing learning activities. Therefore, our initial research interest was to gather information about students' functionally available knowledge about the cognitive and metacognitive strategies they used in actual (not laboratory) classroom learning activities. Furthermore, we were mindful that, in order for our collaborating teachers to fully engage with our research project, they needed to be convinced that cognitive and metacognitive strategies were issues requiring attention, for their own students in their own contexts. Therefore, Study 1 was a large scale survey, in the schools of our collaborating teachers, of students' self-reported cognitive and metacognitive strategy use. The survey was designed to address the following questions:

- What is the level of junior secondary school students' use of cognitive and metacognitive strategies for learning?
- Are there differences in students' cognitive and metacognitive strategy use according to:

a. gender

b. Year Level, and

c. self-reports of coping with schoolwork overall?

A questionnaire was administered to 1388 Year 7[1], 8 and 9 students attending three metropolitan secondary schools in Adelaide, South Australia, in 2007. Two schools were rated as minimum disadvantage schools on the Departmental Index of Educational Disadvantage[2] with, respectively, 12 and 17 per cent of students receiving school fee relief. The third school was rated as high disadvantage with approximately 79 per cent of students receiving fee relief. The proportion of students identifying as Aboriginal or Torres Strait Islander was less than one per cent in each of the first two schools, and approximately nine per cent in the third school.

The questionnaire contained items about living and learning at school, including questions about bullying, friendships, popularity, coping with schoolwork, and cognitive and metacognitive strategy use. Students' responses to the latter three topics are of interest in this paper.

The design of the cognitive and metacognitive items in the questionnaire began with Mayer's (1998) framework of will, skill and metaskill. Mayer has argued that in any instance of problem solving, (learning is a particular case of problem solving), there are three broad factors of influence: motivation (will), cognition (skill), and metacognition (metaskill). Mayer's first category, motivational factors, provides critical influences on learning and performance. However, the focus of this paper is on the latter two categories, namely cognitive and metacognitive skills for learning.

For the design of questionnaire items, we also drew from the conceptual analyses of Lawson (1984), Weinstein and Mayer (1986), Nelson (1996) and Schraw (1994; 1998), and we reviewed previous questionnaires and checklists, (such as

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[1] The year 7 students were temporarily attending the secondary schools as part of the transition program.

[2] The Index of Educational Disadvantage was developed using a combination of Education Department and Australian Bureau of Statistics data. It groups all schools into one of seven ranks of educational disadvantage based on four measures: parental income; parental education and occupation; Aboriginality; and student mobility.

PALS, Midgley et al., 2000; MSLQ, Pintrich & DeGroot, 1990; SEM, Schraw & Dennison, 1994). For the cognitive items, we were mindful of Mayer's (1998) three stages of knowledge acquisition, namely, focussing attention, elaborative processing, and organising and summarising. For the metacognitive items, we adopted the conceptual categories of monitoring of knowledge, and control of thinking processes and learning activities (e.g., see Pintrich, 2004). A large number of potential items were identified, which we refined to meet three criteria, namely, 1) the strategies were consistently identified in the literature as key contributors for good quality learning, 2) the strategies were salient to our collaborating teachers' classroom contexts, and 3) the strategies were suitable for incorporation into the instructional interventions planned for the later stages of our research project.

Students were asked to respond on 7-point Likert scales, Strongly Disagree (1) to Strongly Agree (7), to each item in the cognitive and metacognitive scales. The questionnaire items are shown in Table 1.

We were also interested in providing feedback to teachers about their students' perspectives about how well the students felt they were coping with their schoolwork. The concept of coping is well represented in the literature in areas such as coping with stressors in general (Brodzinsky et al., 1992; Frydenberg & Lewis, 1993), coping with school failure (Rijavec & Brdar, 1997) and coping with bullying (Slee, Murray-Harvey, & Wotherspoon, 2008). In addition, as part of our broader research project (but not the focus of the present paper), 17 interviews were conducted with students to gather their extended views about the issues raised in the questionnaires in Study 1. From these interviews we able to verify that students held similar interpretations to ours about the word 'coping', indicating that the word coping was part of the regular language used by middle-school students (Krosnick, 1999), and providing verification of the cognitive validity (Koskey, Karabenick, Woolley, Bonney, & Dever, 2010) of the concept of coping.

For practical reasons it was not possible to include an extended set of scale items to measure the construct ‘coping with school work’. However, previous studies lend support to the validity and reliability of a single item to measure personal assessments. For example, Hürny et al. (1995) demonstrated that a single item scale was comparable to a 28 item adjective checklist for measuring emotional wellbeing. Similarly, de Boer et al. (2004) found that a single item quality of life scale showed good validity, excellent reliability, moderate distribution-based responsiveness and good anchor-based responsiveness compared to multi-item questionnaires. Furthermore, Abdel-Khalek (2006) found that a single item scale for happiness was reliable, valid and viable, with highly significant correlations in the expected directions with multiple item benchmark scales. Thus, in the present study, we determined that useful information, for both research purposes and for the students’ teachers, could be obtained by asking students to rate themselves, on a five-point Likert-type scale (‘Mostly I Don’t Cope’ to ‘Very Well’), in response to the following item: “Overall, how well do you cope with schoolwork?”

Study 1: Results and Discussion

Questionnaires with invalid responses were discarded, so the final sample comprised 1375 students. Nine per cent of students reported that their parents spoke a language other than English at home. Students’ ages ranged from 11 to 15 years (M = 13.4 years; SD = 0.94), with 51% boys.

For purposes of ongoing discussions with our collaborating teachers, we were interested in maintaining a two factor model to represent separately the theoretical concepts of metacognition and cognition. The two scales were each tested as one-factor congeneric models using Robust Maximum Likelihood analysis in MPlus (version 5.21). The MPlus diagnostics suggested that each model fitted the data well (see Appendix A).

Year Level and Gender differences

As illustrated in Figures 1 and 2, the mean scores for students' metacognitive and cognitive strategy use hovered between scores four and five on the seven point Likert scales. Thus, mean scores were at, or slightly above the neutral point. In the statistical analyses reported in the following sections, estimates of effect sizes were obtained by calculating r [$\sqrt{(t^2/(t^2 + df))}$] of planned contrasts between pairs of groups using t-tests (Field, 2009). In the univariate analyses of variance, effect sizes were estimated by converting F to r using the F-ratio and the residual degrees of freedom.

Metacognitive strategy use

Univariate analysis of variance indicated significant effects of Gender, F (1, 1347) = 13.9, $p < .001$, $r = .10$, and Year Level, F (2, 1347) = 10.6, $p < .001$, and also a Year Level and Gender interaction effect, F (2, 1347) = 4.0, $p < .05$, on the metacognitive strategy use factor. Higher scores on the metacognitive strategy use factor were more evident for males in Year 7 than for males in Years 8 and 9. As displayed in Figure 1, males' and females' strategy use was similar at Year 7 but females recorded higher scores in the later Year Levels.

A simple effects analysis indicated that in Year 7 there was no overall significant difference between males and females on metacognitive strategy use. However, females were more likely to have higher metacognitive strategy use scores than males in Year 8, F (1, 1349) = 15.7, $p < .001$, $r = .11$, and in Year 9, F (1, 1349) = 5.6, $p < .05$, $r = .06$. In addition, metacognitive scale scores decreased across Year

Levels for males, F (2, 1348) = 11.1, $p < .001$, and females, F (2, 1348) = 3.3, $p < .05$. Post hoc tests found higher metacognitive scores for males in Year 7 compared to Year 8 (t (456.1) = 4.16, $p < .001$, $r = .19$) and Year 9 (t (392.2) = 4.17, $p < .001$, $r = .21$) but no significant difference between males in Year 8 and 9 on this factor. Only between Year 7 and Year 9 were significant differences evident for females on the metacognitive factor (t (441) = 2.05, $p < .05$, $r = .10$).

Cognitive strategy use

Univariate analysis of variance found no significant effects of Gender, F (1, 1327) = 3.3, $p > .05$, $r = .05$, and a Year Level effect, F (2, 1327) = 10.1, $p < .001$. There was a Year Level and Gender interaction effect, F (2, 1327) = 3.6, $p < .05$, on the cognitive strategy use factor. Higher cognitive strategy use scores were evident in the Year 7 students' scores compared to the Year 8 and 9 students' scores. Post-hoc tests showed that Year 8 and Year 9 students did not differ significantly on this scale (Year 7/8s, t (860) = 3.9, $p < .001$, $r = .13$; Year 7/9, t (713.1) = 3.9, $p < .001$, $r = .15$). As shown in Figure 2, the level of reported strategy use for males was notably lower in Year 8.

A simple effects analysis indicated that only in Year 8 was there a significant difference in cognitive strategy use between males and females, F (1, 1329) = 7.3, $p < .01$, $r = .09$, and only for males was a significant decrease in cognitive strategies evident across Year Levels, F (2, 1328) = 12.1, $p < .001$. Post hoc tests indicated that males in Year 7 had higher metacognitive strategy use scores than males in Year 8 (t (438.9) = 4.51, $p < .001$, $r = .21$) and in Year 9 (t (383.0) = 3.89, $p < .0001$, $r = .19$), although no significant difference was found between Year 8 and Year 9 males on this scale.

Whereas Hattie (2009), in his large-scale meta-analysis, found practical effects for gender differences in responses to computer instruction, he argued for negligible differences in overall academic achievement outcomes between boys and girls. Findings about gender differences from the Program for International Student Assessment (PISA) (OECD, 2009; OECD, 2010) for 15 and 16 year old students are mixed, with ongoing (2000 to 2009) differences favouring girls for reading, favouring boys for mathematics, and no overall (but varying sub-scale) gender differences in science scores (notably, in Australia). A key finding from the PISA 2006 (OECD 2009) was that there were no statistically significant differences in problem solving scores for males and females. However, of particular interest to the present paper is that,

> in all but a few countries, students who use appropriate strategies to understand and remember what they read, such as underlining important parts of the texts or discussing what they read with other people, perform at least 73 points higher in the PISA assessment – that is, one full proficiency level or nearly two full school years – than students who use these strategies the least….[and that girls] are more aware of effective strategies to summarise information than boys. (OECD, 2010, p.12)

The gender differences observed in the present study show some differences between boys' and girls' use of cognitive and metacognitive strategies. A study by Else-Quest, Hyde, Goldsmith and Hulle (2006) about gender differences in temperament showed differences, favouring girls, in effortful control, including attention, persistence, and inhibitory control. Although relating to temperament, rather than the cognitive and metacognitive strategy focus of this paper, the constructs of regulating attention, persistence and inhibiting impulses are salient for classroom activities, thus suggesting some corroboration of the gender differences observed in the present study.

It might be expected that, as students mature and are exposed to more years of schooling, they would demonstrate increased facility in their use of effective cognitive and metacognitive strategies for learning. There is recent evidence that well-designed learning tasks can be associated with growth in strategy knowledge in early secondary school (Spörer & Brunstein, 2009). In this respect, the falling patterns of cognitive and metacognitive strategy use across the three Year Levels displayed in Figures 1 and 2 are concerning. These falling response patterns were observed across all three participating schools. One possible interpretation of this finding is that the older students interpreted the questionnaire items differently to the younger students, and therefore gave different responses. However, the language of the questionnaire items was straightforward, and although the strategies, such as ‘discussions’ or ‘draw pictures or diagrams’ or ‘ask a question’ might be enacted in different ways by younger or older students, our interpretation is that each strategy type was sufficiently clear, such that both younger and older students could recognise whether they did, or did not, use that strategy type. In our previous interview research with school students, questions such as these have been interpreted in the ways that we intended (e.g., Askell-Williams & Lawson, 2005a; 2005b). Thus we interpret the falling pattern across Year Levels as a valid reflection of students’ reported strategy use. Of most significance is that the direction of reported strategy use did not rise, as might be expected if students were developing more powerful explicit knowledge about learning strategies.

Two possible reasons for such a pattern seem relevant. First, research reports indicate that growth in strategy knowledge does not appear to be an automatic outcome of all classroom learning. For example, Koriat and Bjork (2006) and Herzog, Price and Dunlosky (2008) have argued that growth in strategy knowledge requires appropriate metacognitive activity, so that the generation of more precise knowledge about strategy effectiveness will be stimulated by performance monitoring and by linking the outcomes of monitoring to the prior strategy knowledge (Winne, 1996).

The second reason emerged during discussions with our collaborating teachers. They suggested that there was a relatively greater emphasis on subject-matter teaching as students undergo transition into middle school (Years 8 and 9), compared to more explicit teaching and scaffolding of strategies for learning in the primary school years (Year 7). The strong sense gained from our discussions with our collaborating teachers was that primary school teachers adopt a broad mandate for teaching across multiple subject areas and for supporting students to learn. In contrast, we were advised that many secondary school teachers are subject-matter focussed, and assume that students are already well-equipped with strategies for learning. The results from Study 1 suggest that a subject-matter focus may be to the detriment of students maintaining and further developing their expertise about cognitive and metacognitive strategies for learning. This interpretation is strengthened when considering students' reports of their ability to cope with school work.

Coping with schoolwork

Bivariate correlation analysis indicated that students who reported using higher levels of cognitive and metacognitive strategies were more likely to report that they were coping well with school work (cognitive: $r = .13$, $p < .001$; metacognitive: $r = .21$, $p < .001$). From the group profiles displayed in Figures 3 and 4 it can be seen that there are hierarchical patterns of cognitive and metacognitive strategy use according to students' coping status. Additionally, it can be seen from the group profiles in Figure 4 that the items 'I draw pictures and diagrams' and 'I make up questions' were low for all groups and thus became one focus of the instructional interventions reported in Study 2, below.

Furthermore, when students who were considered to be 'of concern' (i.e. responding 'mostly I don't cope' or 'not very well' $n = 88$) were compared with students who responded 'very well' ($n = 193$), a univariate analysis of variance showed that students who coped very well with school work were significantly more likely to report that they were using metacognitive strategies, F (1, 274) = 21.8, $p < .001$, $r = 0.27$, than students who were not coping well with school work. Mean metacognitive scores (with standard deviations in parentheses) for students who coped well and did not cope well with schoolwork were 3.9 (1.4) and 4.7 (1.4), respectively. Similarly, students who reported that they were not coping with school work were found to differ from students who reported they were coping very well with school work with respect to cognitive strategy use, F (1, 271) = 9.2, $p < 0.01$, $r = 0.18$. For students who reported not coping well and coping well with schoolwork, the mean cognitive scores were 4.1 (1.4) and 4.6 (1.4), respectively.

The findings from Study 1, when relayed back to staff in participating schools, had a powerful effect. Rather than hearing about research reports from distant contexts, school leaders and teachers were faced with data that had direct relevance to their own settings. This led to some teachers volunteering to participate in the classroom interventions described in Studies 2 and 3.

Studies 2 and 3: Classroom instructional interventions

We designed classroom instructional interventions to investigate the impact of teachers' use of a tool designed to scaffold students' development of expertise in cognitive and metacognitive strategies for learning. The instructional tool was a paper-based, just-in-time, prompted, written learning protocol.

Berthold, Nückles and Renkl (2007) had suggested the use of prompted and supported learning protocols (guided reflective journals) to provoke students to engage reflectively with their cognitive and metacognitive strategy use (Berthold et al., 2007; Hübner, Nückles, & Renkl, 2010; Nückles et al., 2009). Such evocation of students' explicit awareness and reflection were key components of our intentions for the proposed instructional interventions. However, conversations with our collaborating teachers suggested a number of practical difficulties with employing the Berthold et al. procedure in typical South Australian classrooms. These difficulties included that, the selected cohorts of students would be unlikely to persist with extended writing tasks; there would be limited time in class for an extended writing task that was not part of the set curriculum, nor assessed; and if relegated to a homework task, a learning protocol would probably not be completed by most of the students. The teachers indicated that they preferred small, rapid intervention modules that could be easily fitted into the everyday structures and processes of lessons, as suggested by Kalyuga (2006).

We therefore adapted Berthold et al's (2007) ideas about learning protocols and created a brief, prompted, written-response protocol that could be inserted in short 'bites' into regular class lessons without substantially changing typical class routines. The design of the learning protocols drew from work on advance organisers (Ausubel, 1960), where we sought to provoke students to bring into their working memories concepts that would assist their cognitive engagement with the lesson. The prompts in the learning protocol, consistent with the design of the questionnaire used in Study 1, were drawn from Mayer's (1998) three stages of knowledge acquisition (focussing attention; elaborative processing; organising and summarizing), with the addition of monitoring understanding about subject-matter in order to capture metacognitive activity (Flavell, 1979; Nelson, 1996; Schraw, 1994). These four components are presented in more detail in the following section.

Focussing Attention on key ideas: Select

Focussing attention on the key information to be learned is an early step in information acquisition (Anderson, 2010; Butler & Winne, 1995). However, some students do not effectively focus on the lesson's main concepts. Thus, the first component of the learning protocol was designed to prompt students to specifically attend to the key ideas of lessons.

Elaboration of key ideas: Relate

Next, the key ideas in the lesson need to be elaborated and connected to other knowledge frameworks. Elaboration is a complex cognitive activity (Hugener et al., 2009). In elaborating their knowledge, students go beyond the information given (Bruner, 1973) to make external connections to prior knowledge, or to generate examples, create metaphors, analogies, and abstract knowledge (Weinstein & Mayer, 1986). The second component of the learning protocol included prompts to provoke students to make connections between new information and their existing mental models.

Structuring of key ideas: Organise

The third component of the learning protocol was to prompt students to organise their knowledge, which is also a complex learning activity (Hugener et al., 2009). Knowledge organisation requires a learner to identify the internal meaningful relations between key ideas (Weinstein & Mayer, 1986). Organised knowledge is more amenable to abstraction and inspection, and therefore more likely to be stored with understanding and functionality for future use (Karmiloff-Smith, 1992). In a reciprocal fashion, the deliberate use of cognitive organisational strategies improves students' ability to make connections between ideas and promotes understanding of content domains (e.g., Mintzes & Novak, 2000; Pearsall, Skipper, & Mintzes, 1997; White & Gunstone, 1992).

Monitoring understanding of key ideas: Check

The fourth component of the learning protocol was designed to prompt students to check their understanding of the lesson content. Metacognitive awareness is a key component of good quality learning (Mattick & Knight, 2007). Knowing what you know provides the schema for acquiring new knowledge (Anderson, 2010). Knowing what you don't know has the potential to provoke the search for clarification (Chi, Bassok, Lewis, Reimann, & Glaser, 1989). Hattie (2009) argued that although feedback from teachers to students is common, other types of feedback, such as feedback from students to teachers, and student self-feedback, are also essential to guide powerful instructional designs and learning. This fourth component of the learning protocol was designed with these two latter types of feedback in mind.

Table 2 summarises the component of interest (Column 1), the prompts (Column 2), and the supporting theory (Column 3), used in the design of the learning protocols that were used in Studies 2 and 3. From the perspective of bridging the research to practice gap, we were mindful that the learning protocols needed to:

- Make explicit connections between theory and practice in order to assist *teachers* to learn more about how people learn,
- Be seen by teachers as being directly related to their instructional intentions for their planned curricula,
- Take little time/effort to implement or add-in to regularly planned lessons,
- Scaffold *students* to engage in cognitive and metacognitive strategy use, and
- Provide feedback to both teachers and students about students' cognition and metacognition.

The research questions for Studies 2 and 3 were:

1. Can a cognitive and metacognitive strategy tool (written learning protocol) be readily incorporated into regular class lessons?
2. Will in-class use of the cognitive and metacognitive tool be associated with change in students' reported use of cognitive and metacognitive strategies?

Classroom delivery of the learning protocols

The instructional interventions consisted of the employment of the learning protocols by two teachers who volunteered to join the research project and to involve their classes: A Year 9 Science class (in 2008), and a Year 11 Psychology class (in 2009). The learning protocols were employed during regular class lessons, elaborated with explicit verbal instructions from the researchers and/or teachers, and completed by students at suitable times.

Implementation of Study 2: The Year 9 Science class in 2008

In school terms 2, 3 and 4 of 2008 we attended one or two science lessons each week (9-11 weeks per school term) with the Year 9 class of 28 students. All students participated in the instructional interventions, with eight boys and seven girls (and their parents/carers) consenting to the use of their data in research reports.

We delivered an introductory lesson that included explicit instruction about cognitive and metacognitive strategies and the value, for learning, of using such strategies. Over the ensuing weeks, students were directed to complete the various sections of the single-page learning protocols, which were distributed at the start of the lesson with supporting prompts and explicit instruction. The in-class procedure for using the protocols was as follows:

Select

We provided the teacher with a lesson start-up script, which was delivered verbally by the teacher at the beginning of selected lessons, as follows:

1. Today's lesson is about …………..
2. The key ideas in today's lesson will be ………..
3. The learning activities in today's lesson will be …………
4. Please complete the 'Select' section of the written protocol.

The teacher script and use of the student learning protocols were repeated over a variable number of lessons each week (according to the school timetable) to reinforce strategies for tuning-in to the lesson.

Relate

During lessons, the teacher provided verbal prompts to students to cue relationships between the information to be learned and students' prior knowledge. As one example, in a lesson about polymers, the teacher asked students to discuss their knowledge about everyday uses for plastics (e.g., PVC stormwater pipes). Students were then asked to record in their protocols 'what they already knew' about the topic.

Organise

Students were provided with explicit instruction about strategies for organising subject-matter knowledge, such as highlighting and/or noting text features such as headings. In particular, the researchers delivered lessons about drawing diagrams and concept maps which the teacher followed-up with in-class opportunities for further practice. Students were prompted to record the various strategies for organising knowledge in their learning protocols.

Check

At the end of lessons students were asked to respond to questions in the learning protocol about their understanding of the lesson content. For example, students were asked, "What is something that you didn't really understand well in this lesson?" Students were also encouraged to take steps to remedy any lack of understanding, with prompts such as, "You could ask a question."

Throughout the school terms we held regular meetings with the class teacher to discuss how the learning protocols and learning strategy instruction could be fitted into his lesson plans. As the school year progressed, we gradually transferred responsibility for delivering instruction related to the learning protocols from ourselves to the class teacher such that, whereas at the beginning of the intervention the learning strategy instruction was delivered by the researchers (authors), the learning strategy instruction was eventually delivered by the class teacher following discussion with the researchers at weekly planning meetings.

Results and discussion from the Year 9 Science class intervention

In total, during school Terms 2, 3 and 4 the learning protocols were employed in 37 science lessons. Students' learning protocols, text book responses, concept maps, audio-recorded verbal responses to instructional questions, and formative and summative tests were collected to form the data base for this study. In the following section, we first report findings related to each of the components of the learning protocol.

Select

The teacher's lesson start-up scripts, such as "Today's lesson is about chemical reactions", provided clear cues about lesson topics that students recorded on their learning protocols. Students' protocol responses to the question, "What is today's lesson about?" reflected that the students were able to tune-in to the teacher's start-up script, and provide correct responses such as "energy changes in chemical reactions" and "mass before and mass after". Overall, throughout the period of data collection, the learning protocols and work samples indicated that students were able to identify the intended foci of lessons.

Relate

The learning protocols also provided records of students' intended learning strategies, which were variable. For example, Table 3, which covers a seven week period during

August to September, shows contributions from Abu, who could generate a number of different strategies for learning, while Shu responded with comments about what she needed to remember, as well as metacognitive judgments about whether she thought she would remember. However, inspection of other profiles shows some substantially impoverished strategy knowledge, such as the profile of Jth, who referred to one strategy: “Writing (and staring at it)”.

From Table 3 we can identify a group of four boys and one girl (Cci, Lga, Jth, Pmo, Cro) who reported simple, unelaborated procedures. The explicit knowledge of these students seems unlikely to cue them to transform their science content knowledge in ways that would generate effective connections between key ideas. We can compare this to Shu and Dob, who reported procedures that involved making connections both with prior knowledge, and among parts of the current lesson materials. Although some students’ profiles, such as Abu’s, appeared to improve over the course of our instructional interventions, other profiles remained stable, such as Dob’s. Thus Table 3 displays no clear pattern of improvement, at the class level, in the Year 9 students’ explicit knowledge about learning strategies over the first six weeks of the instructional intervention.

A more detailed account of strategy use is available from Table 4 that represents 42 data collection events across a four week period, specifically about relating the current lesson topic to information that the students might already know. Excluding absences (17), there were 25 responses. Of these 25 responses, approximately one third (8) involved minimal cognitive relating activities (either repetitions of the lesson topic or no response). Five responses (20%) involved a simple, often single, connection to relevant knowledge. The remaining 12 (48%) responses involved more substantial relations to existing knowledge, either to related concepts or to practical examples. In these latter cases, students generated a greater number of connections that could potentially be linked into knowledge networks.

There are three possible interpretations of the students' responses about strategies for learning and, in particular, relating knowledge, in Tables 3 and 4. The first is that students did not hold existing mental models that would act as foundations for the next lessons on the topics in the prescribed science curriculum (such as energy, mass, matter). The frequency of student absences provides one explanation for the large gaps in students' prior knowledge. In this respect, the feedback in the students' learning protocols could have alerted the teacher to revise subsequent lesson plans to account for gaps in students' prior knowledge. A second possible interpretation is that neither the teacher nor the students were cognisant of the need to evoke students' existing mental models in order to provoke the relational knowledge that would equip students to more fully engage with the topic of the day. And third, it is possible that the students lacked strategies to help them to set up relationships between the new information and their existing knowledge.

Organise

From the pattern of results in Study 1 we predicted that students would lack knowledge about one group of strategies in particular, namely, drawing diagrams and concept maps (White & Gunstone, 1992). Therefore, in one component of Study 2 we provided explicit and extended instruction about how to draw diagrams and concept maps. Table 5 represents 60 data collection events (May to October) where opportunities to draw diagrams or concept maps were provided to students. Seven events record student absences, leaving 53 events where such drawing could have occurred, and did occur in about 50% (26) of these events (cells are shaded in Table 5). From Column 2 in Table 5 it can be observed that no students drew diagrams or concept maps in a test on 21/05/2008. Over the following six months the profiles changed, such that most students generated diagrams or concept maps in the final test. In the two earlier occasions there are 7/28 drawings recorded (25%), compared to 19/25 (76%) in the latter two occasions, which indicates meaningful improvement (Wilcoxon signed-rank test: $z = 2.6$, $p < .01$, $r = .67$). An example of a student's integration of a diagram into a summative test is provided in Figure 5.

Check

The final section of the written learning protocol was designed to provoke students to reflect upon the key points of the lesson, and to identify at least one issue that they did not understand. Although many students provided limited responses to this final section of the protocol, some students presented at least one point of confident knowledge and one point of confusion. Table 6 displays a summary of students' responses to the 'check' section of the protocol on three data collection occasions. A first impression from Table 6 is, once again, the large number of student absences, which must have an impact upon the quantity and continuity of knowledge that students can bring to class. Discussions with the class teacher indicated that these patterns of absence are typical at this Year Level, where many activities compete for lesson time (such as sports carnivals, theatre performances, and school camps). Of 26 possible responses from students in attendance, 13 (50%) indicated no response. Of the remaining 13 responses, eight (shown as shaded in Table 6) provided the teacher with specific feedback or a specific question.

Although overall the students' responses to 'check' were impoverished, their responses did generate some important teaching actions. For example, when the teacher reviewed the learning protocols it became evident that certain aspects of lessons, that the teacher had thought worked well, had not been well-understood by students. This led to the teacher making plans to revise and repeat some topics. One illustration of this followed a lesson about sound waves, where the teacher employed a long, slinky spring to visually demonstrate transverse and longitudinal wave motion. The teacher’s analogy, between waves in the slinky spring and sound waves, was not understood by some students, leading to responses on the learning protocols such as, “The slinky thing confused me with how it tied in with hearing stuff.” The teacher revised subsequent lesson designs, illustrating Hattie’s (2009) argument about the power of feedback for promoting learning, not just when feedback occurs as regularly expected from teachers to students, but also in the reverse direction, from students to teachers.

Summary of Study 2: Year 9 science class interventions

Positive outcomes were evident for two of the four learning protocol components, namely, the attention focusing and diagramming/concept mapping components. Less progress was observed in students’ accounts of strategies for identifying relationships between items of information, or of checking understanding of lesson content. In considering why these patterns emerged, the first, calling on students’ attention, is a typical teaching strategy: It is thus likely to be recognised by students, and so may be more readily actioned than the other components of the protocol. It was also noted that, due to our intervention, diagramming/concept mapping might have received more explicit attention in the class lessons. Overall, however, at the whole class level, students’ explicit awareness of their cognitive and metacognitive strategies was disappointingly low, although some individual students made progress.

During our post-intervention reflections we hypothesised that a possible influence on students’ uptake of learning strategies was that the classroom interventions continued to be viewed, by the participating teacher and the students, as researcher driven ‘add-ons’ to the prescribed curriculum. Initiatives that are considered to be appended to the recognised core curriculum suffer from perceptions that they are not essential, and have low status due to lack of teacher-ownership, and because such subjects are typically not examined to a set of standards (Shucksmith, Philip, Spratt, & Watson, 2005). As such, addendums are likely to be dropped when time pressures, costs, or skill limitations make their maintenance difficult. The alternative, namely, embedding the initiative in the regular curriculum, is a current aim of innovative curriculum designers across a number of fields (e.g., for the arts, see Ewing, 2011; for cross-curriculum priorities, see ACARA, n.d.; for mental health promotion in schools, see MindMatters, 2010)).

In the current study, this ‘add-on’ perception appeared to detract from participants’ assessments of the value of the learning strategy instruction for their everyday jobs: for the ways that teachers and students should be acting while engaged in lessons. We reflected that perhaps we had not sold the value of the instructional intervention as effectively as we might have to the participating teachers and students. This was perhaps exacerbated by our continued ‘researcher’ presence in class lessons.

We determined that to better integrate cognitive and metacognitive strategy instruction into the fabric of regular class lessons, we needed to more fully demonstrate to class teachers the value of such instruction, so that they could more personally engage with, and take responsibility for, delivering such instruction. Furthermore, we needed to work even more closely with class teachers to match the learning protocol interventions with the prescribed subject-matter curriculum designs. This evaluation of the progress and outcomes of the learning protocol intervention in Study 2 led to revisions of the intervention designs for the next stage of the project.

Implementation of Study 3: The Year 11 Psychology class in 2009

In School Terms 2 and 3 of 2009 we worked with another teacher at a different partner school to incorporate the written learning protocols into regular lessons with her Year 11 Psychology students. All 26 students participated in the instructional interventions, and all students (and their parents/carers) consented to using students' data and work samples in research reports.

In Study 3 we were keen to hand over more responsibility for the in-class delivery of the instructional intervention to the class teacher. Therefore, we (the researchers) did not work directly with the students. To begin the intervention in Term 2 of the school year, we held a series of meetings with the class teacher where we, discussed cognitive and metacognitive strategy instruction; adapted the written learning protocol to the teacher's planned subject-matter for the term; and designed a week-by-week plan for integrating delivery of the learning protocol and associated strategy instruction in conjunction with the set curriculum topics. In Term 3, the teacher delivered the planned subject-matter curriculum in conjunction with instruction and guided practice in cognitive and metacognitive strategy use, employing the structured learning protocols to scaffold the weekly lesson deliveries. The procedure for the use of the learning protocols was the same as detailed above for the Year 9 science class, with the exception that the teacher assumed full responsibility for lesson delivery.

Results and discussion from the Year 11 Psychology class intervention

At the end of School Term 3 we collected all of the learning protocols generated during the term by the Year 11 students. From this large data base, we sorted and categorised the students' responses into themes generated from the original literature review, questionnaire design and learning protocol design. We retained students' own words to describe examples of each theme. We then compared the examples on students' first learning protocol (pre-intervention), with the examples from the ensuing weeks, as the teacher's instructional interventions using the learning protocols progressed.

The growth in number and quality of examples that describe students' cognitive and metacognitive strategies are detailed in Table 7, from which it can be observed that, compared to the first (pre-intervention) learning protocols, the subsequent learning protocols (during and post-intervention) showed:

- that overall, the number of examples nominated in each of the four sections of the learning protocols more than doubled (17 examples increasing to 43 examples);
- an increase in more complex Relate examples (seven to 19 examples), such as *writing down in my own words, re-arranging information, creating retrieval cues*;
- an increase in examples in the Organise section, (seven to 15 examples), such as *diagrams to link ideas, grouping, chunking* and strategies that focus on retrieval that involve more extensive transformation of ideas, such as *doing test questions, homework, picture where I was in the situation*.
- an increase in the Check section, (one to six examples) of examples that require more generative, or active, involvement by the student for obtaining understanding, such *as asking for help, rethinking what was discussed.*

It must be noted that the examples listed in Table 7 were distributed across the whole class, and across the school term, which means that not every student referred to every example in every lesson. However, at the class level of analysis there is evidence of students' increased references to more elaborated cognitive and metacognitive strategy use across the school term.

In our post-intervention discussions with the collaborating teacher, the teacher commented about the usefulness of the learning protocols for her teaching practice and her students' learning. She indicated that she found that the planned use of the written learning protocols, "Helped me focus on thinking about the variety of strategies used for the topic," and "Helped me focus on thinking about the proportion of higher order thinking skills incorporated." The teacher also reported that her professional observations of the Year 11 class, and her assessment of their final papers, indicated that the instructional intervention had a positive impact upon the quality of students' understanding of the subject-matter.

It could be argued that this feedback from the teacher lacked a set of pre-determined criteria for such an assessment. This is a potential limitation of this research. An alternative perspective, that is particularly suited to the nature of this collaborative, micro-level, class based research, is that the teacher's professional, contextualised, judgement about her students' progress, based upon her daily observations of their in-class learning activities and assessment tasks, has professional validity. We therefore consider that the teachers' professional judgments about her students' learning progress, in the context of this collaborative study, to be valuable feedback. The teacher also advised that she intended to repeat the use of the written learning protocols with her classes in the following year.

It is also of relevance to note that in the year following this intervention with the Year 11 Psychology teacher, the staff of her school decided to use the written learning protocol, (Select-Relate-Organise-Check) framework in other classes. Additionally, a group of teachers in the school used the framework to provide a coping scheme for students subjected to bullying. This was a use of the framework that we had not envisaged. The school adopted a new name for the framework, ‘S. Roc’, to modernise it, and catch the interest of students. This gradual diffusion of the use of the framework gives support to the notion that the Year 11 Psychology teacher regarded the original intervention as valuable, and disseminated her views to other school staff.

As a fitting closure to our collaborative work, at the end of 2008 and 2009, both of our collaborating teachers (Year 9 Science; Year 11 Psychology) presented their positive evaluations of the learning protocol interventions to the annual local teacher/researcher conference on educational futures. This transfer of researcher-led learning strategy instruction into teachers’ classroom practice, and teachers’ dissemination to other teachers, is a further example of a procedure that can help in closing the gap between research and practice.

Limitations

Studies 2 and 3 are case studies in which the focus was on the change, at the class level, in the students’ behaviour across time. Although such a design has important limitations, it is useful in teacher-researcher collaborative classroom-based research, where a strictly experimental design is not as amenable to the needs of the teacher collaborators, nor as feasible to implement given school timetables and curriculum requirements. Of course, these design limitations imply that caution must be heeded when interpreting the findings from the studies. Future studies could investigate change over time in students’ responses and cross-sectional differences between groups.

Conclusions

In this study we inquired about the status of students' cognitive and metacognitive knowledge. Results from Study 1 demonstrated that students' cognitive and metacognitive strategy knowledge was generally at less than optimal levels, with some small differences between boys, girls and Year Levels. Furthermore, there were clear differences in the profiles of cognitive and metacognitive strategy use between students who reported different levels of coping with schoolwork. This evidence was presented to our partner schools, and provoked some teachers' enthusiasm to become engaged with cognitive and metacognitive strategy instruction.

In Studies 2 and 3 we enquired, firstly, about whether the in-class, just-in-time, use of written learning protocols was readily accepted by teachers and students, and secondly, whether the scaffolding provided by the learning protocols raised students' levels of knowledge about useful cognitive and metacognitive strategies for learning. Discussions with participating teachers and classroom observations suggested that the learning protocol was easy to use, time efficient, and had the potential to provoke just-in-time awareness of fruitful cognitive and metacognitive strategies. The ability of the learning protocols to fit into classroom structures provides the potential for embedded and extended use of the protocols in regular class lessons.

The use of the learning protocols first with the Year 9 students (Study 2), and then with the Year 11 students (Study 3), led to some students improving their strategy knowledge, thus potentially counteracting the downward trends observed in the large scale survey in Study 1. However, although some individual students showed substantial progress, at the class level the students in the Year 9 class showed less change in the patterns of their reports of cognitive and metacognitive strategy use over the course of the intervention than we had hoped for. An exception to this was the Year 9 students' responses to the instruction about drawing diagrams and concept maps, which showed increased use of diagrams under test conditions.

Study 3 drew from our experiences in Study 2, and handed more responsibility to the class teacher for using the learning protocols to scaffold cognitive and metacognitive strategy instruction. Analysis of the Year 11 students' learning protocols showed that, at the class level students did generate greater awareness of cognitive and metacognitive strategies suitable for in-class use. Furthermore, the class teacher's assessment was that the learning protocols were a valuable addition to her teaching repertoire to support students' learning.

Reflecting upon these findings, a first observation relates to the power of providing school staff with specific information about the cognitive and metacognitive strategies used by their own students, as we did by presenting to staff the results of the questionnaire. We propose that this is a key first step in eliciting teachers' engagement with cognitive and metacognitive strategy instruction. It might be that this is simply a matter of ownership, with the teachers being more aware of the immediacy of data generated by their own students. Such ownership is predicted to imbue the proposed instructional interventions with more value. An important second step is to dedicate sufficient time to joint researcher-teacher planning of the proposed instructional interventions.

An exciting component of this research project has been to work in partnership with school teachers, and this has included frequent feedback sessions to school staff meetings. Although our capacity was limited to working with one class at a time, following the feedback sessions, other teachers in the participating schools indicated their intentions to incorporate aspects of the cognitive and metacognitive interventions using the learning protocols with their own classes. For example, in 2010 at the same school as the 2009 Year 11 Psychology class, the strategy of making lesson introductions more precise and explicit was adopted by school leadership as a focus for discussion at faculty meetings, and extended to additional classes by some teachers. Other teachers engaged with us in adaptation of the learning protocol for their own lessons in English, and initiated discussions with us about interpreting the feedback obtained from their students, via the learning protocols, from their classes. In 2011, we maintained regular meetings with our school partners, and reports indicated that the school has made further use of the S. Roc framework as it was used in the intervention and in a way we had not anticipated. This snowball effect of the learning protocol to direct teachers' teaching, as well as students' learning, speaks to the functionality of the learning protocol and goes some way towards our overarching aim, which is to reduce the gap between research findings and classroom practice.

Notes

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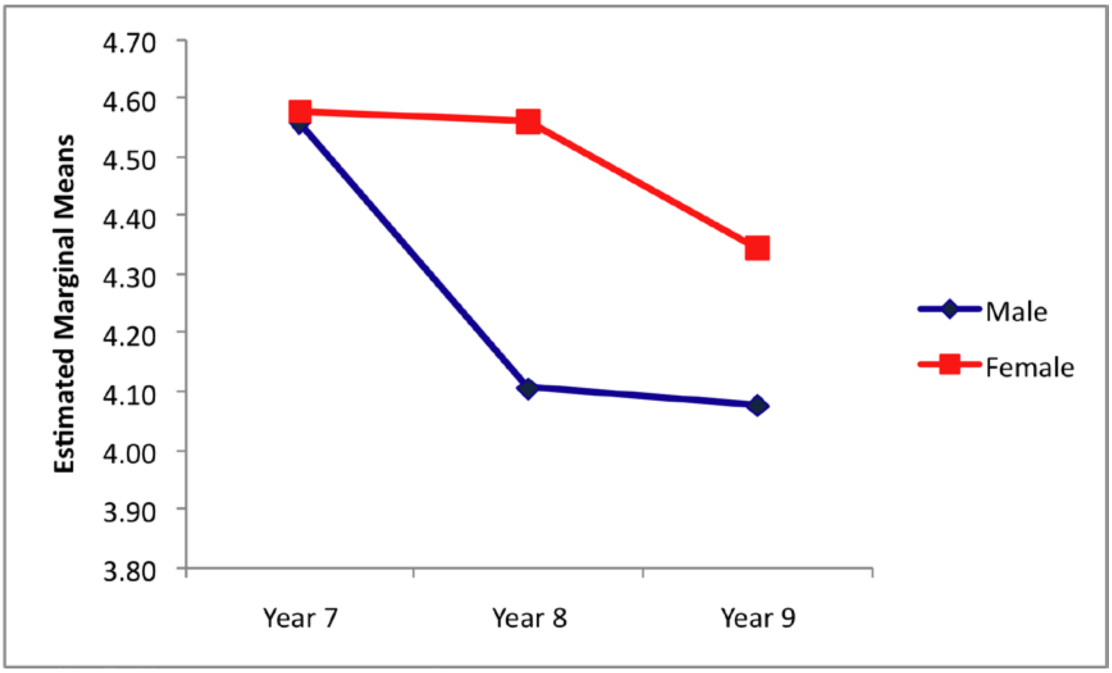


Figure 1: Profiles of Year level and Gender on the Metacognitive Factor (Likert Scale: Low = 1 to High = 7).

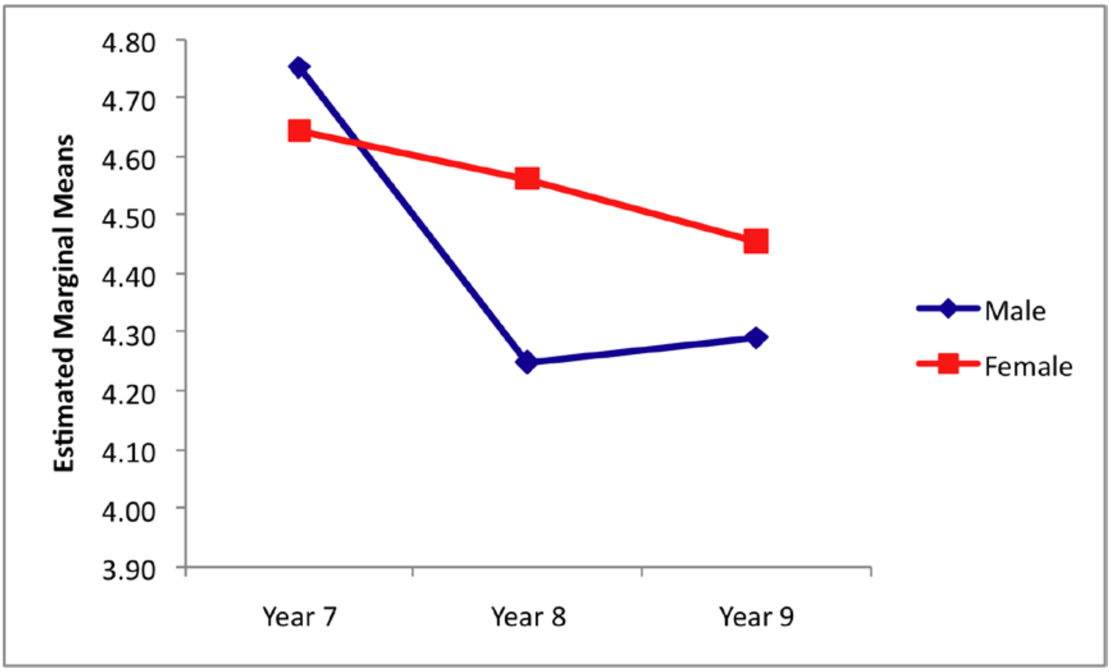


Figure 2: Profiles of Year level and Gender on the Cognitive Factor (Likert Scale: Low = 1 to High = 7).

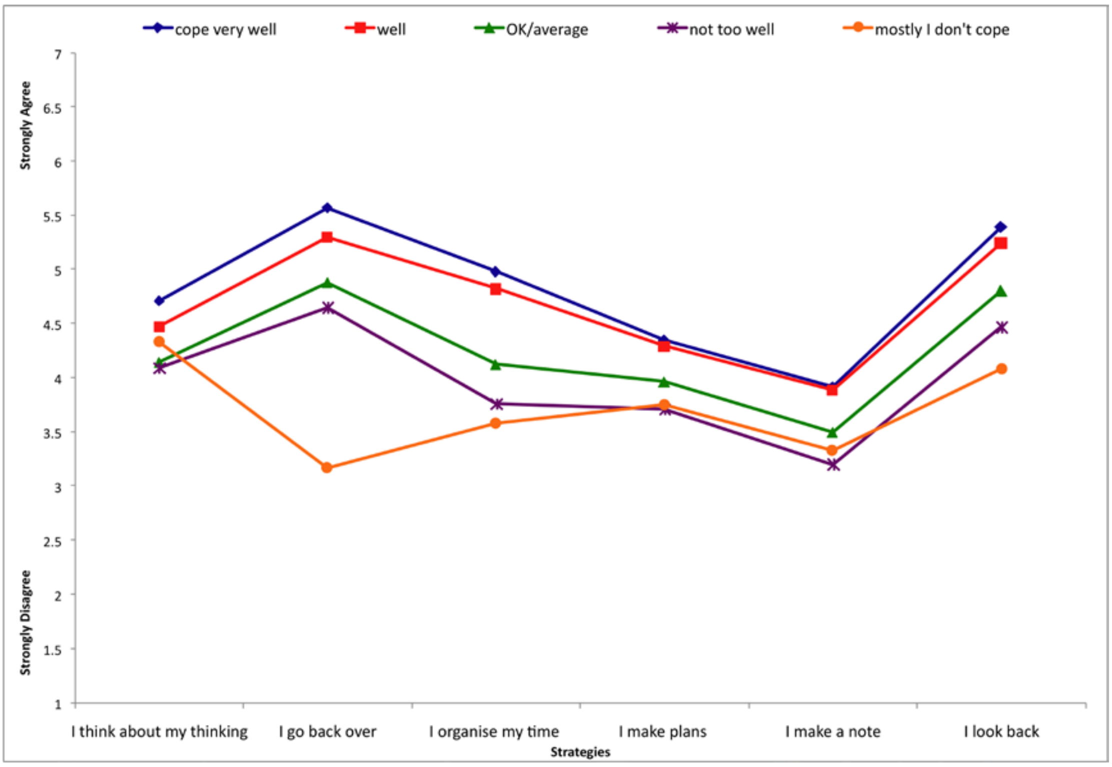


Figure 3: Profiles of mean scores of metacognitive strategy items according to students' self-nominated coping status (Likert Scale: Low = 1 to High = 7).

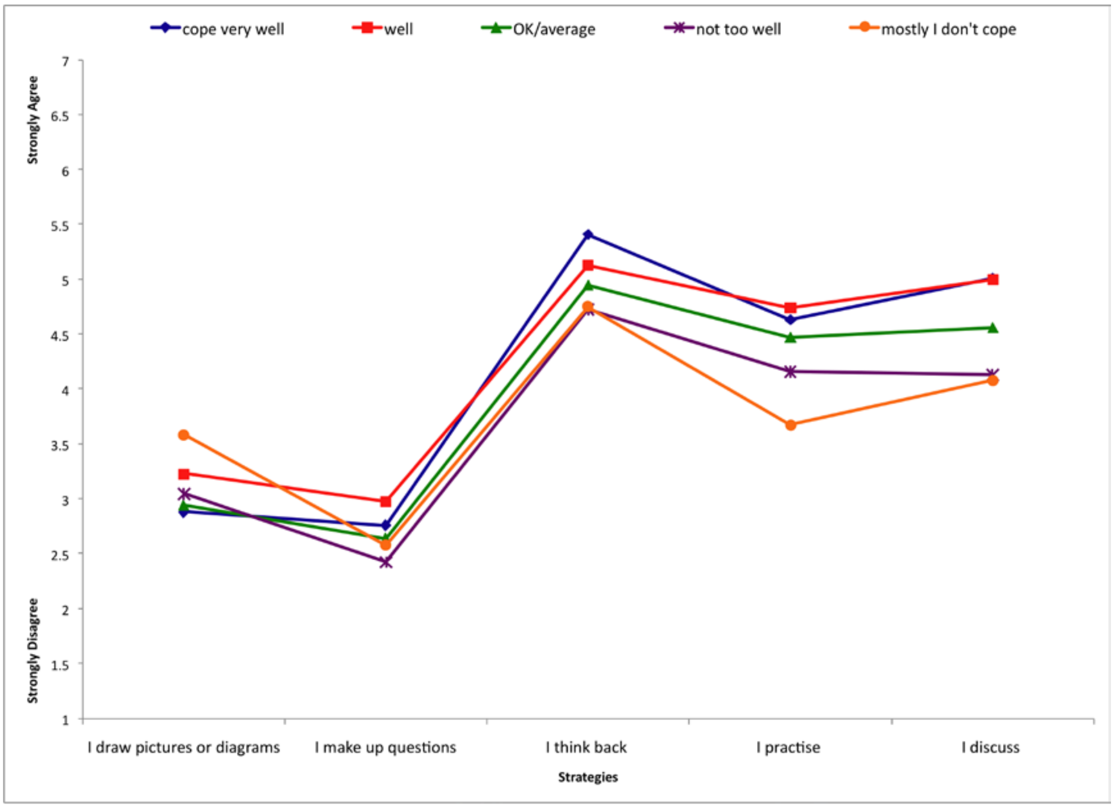


Figure 4: Profiles of mean scores of cognitive strategy items according to students' self-nominated coping status (Likert Scale: Low = 1 to High = 7).

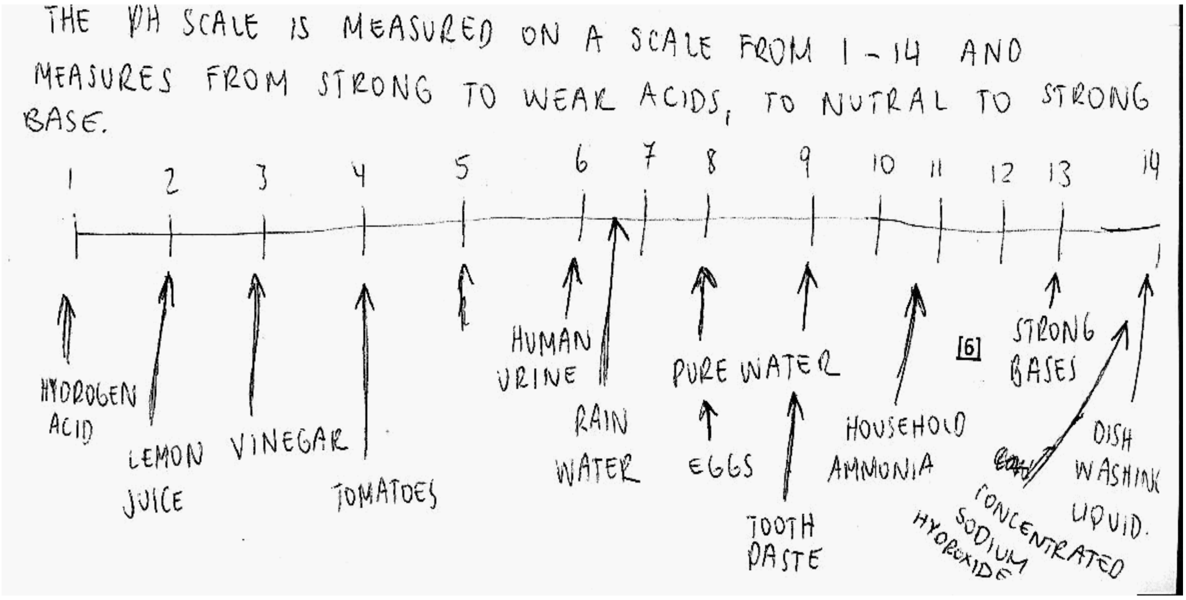


Figure 5: Example of student diagram from summative assessment (29/10/08)

List of Tables

Table 1: Questionnaire items about cognitive and metacognitive strategies

Questionnaire item	*Strategy type*
Cognitive strategies	
I draw pictures or diagrams to help me understand this subject	*Imagery strategy (Knowledge Organisation & Complex Elaboration)*
I make up questions that I try to answer about this subject	*Generative self-questioning strategy (Complex Elaboration)*
When I am learning something new in this subject, I think back to what I already know about it	*Link to prior knowledge strategy (Complex Elaboration)*
I discuss what I am doing in this subject with others	*Generative social learning strategy (Complex Elaboration)*
I practise things over and over until I know them well in this subject	*Repetition strategy (Simple Rehearsal)*
Metacognitive strategies	
I think about my thinking, to check if I understand the ideas in this subject	*Monitoring*
When I don't understand something in this subject I go back over it again	*Monitoring & control*
I make a note of things that I don't understand very well in this subject, so that I can follow them up	*Monitoring & control*
When I have finished an activity in this subject I look back to see how well I did	*Monitoring*
I organise my time to manage my learning in this subject	*Control*
I make plans for how to do the activities in this subject	*Control*

Table 2: Overview of the components of the Select, Relate, Organise and Check Learning Protocol

Component	**Examples of Learning Protocol Prompts**	**Supporting theory for the selection of items**

Identifying Key Ideas (Select)	What is the topic for today's lesson? What will be important ideas in today's lesson?	Attention focusing (Anderson, 2010; Butler & Winne, 1995)
Strategy Instruction (Relate)	What do you already know about this topic? What can you relate this to?	Cognitive Elaboration (Ausubel, 1960; Bruner, 1973; Hugener et al., 2009; Weinstein & Mayer, 1986)
Strategy Instruction (Organise)	What will you do to remember the key ideas (e.g. write down images, or link ideas in a diagram)	Cognitive Organisation (Hugener et al., 2009; Mintzes & Novak, 2000; Pearsall et al., 1997; Weinstein & Mayer, 1986; White & Gunstone, 1992).
Monitoring Understanding (Check)	Is there anything about this topic you don't understand, or are not clear about? (You could ask a question)	Lesson review (Anderson, 2010; Hattie, 2009; Mattick & Knight, 2007)

Table 3: Examples of Year 9 science students' learning strategies (retaining students' own words) on six occasions

Student ID and gender	**1/08/08 (energy changes)**	**4/08/08 (periodic table)**	**6/08/08 (mass)**	**26/08/2008 (chemical reactions)**	**15/09/08 (polymers)**	**17/09/08 (natural polymers)**
Tsm (f)	Listen	*Absent*	No response	No response	*Absent*	*Absent*
Cci (m)	I don't know. I write everything down	Do that thing	Do that thing	Read it	Read it a lot	Try really hard
Aba (m)	Study for them	Discuss it with other people	Do tests on it to learn more	*Absent*	Write it down; memorise it	Read it; write it down; draw pictures
Sma (m)	Read it from a book every now and then	Read about them	Do tests on it	Read it until I have memorised it. Take a photo	*Absent*	*Absent*
Abu (m)	Pay attention to the teacher	Listen	Listen to Mr E.	Read the text book. Review your answers.	Listen to Mr. E. Look back at this sheet. Look in text book	Listen to Mr. E. Look back at this sheet Look in text book Ask Mr E.
Lga (m)	Listen to Mr E.	Listen to Mr E.	Listen to Mr E.	Look at things on the board. Look at the chapter overnight.	*Absent*	Listen, look it up
Jth (m)	Write it lots of times	No response	Write it down	Write it down and stare at it	*Absent*	*Absent*
Pmo (m)	Listen to what Mr E. has to say	Listen to the teacher	Write it down in our books	*Absent*	*Absent*	*Absent*
Tlo (f)	Energy, photosynthesis, sunlight + H2O = food + O2	No response	No response	Study	they're common - polyesther, polythene, polystyrene, PVC	read this [worksheet]

Dco (f)	Energy-get different examples	Memorise periodic table	Do an experiment	No response	Polymers are very common - polystyrene=foam, polythene = food wrap/plastic bags, poly = many, mer = units	Hair, wool, fur, cotton, protein are natural polymers
Shu (f)	Try to go over them, I think I will remember heat, light and sound easily, I need to remember that chemical energy is food. Might be able to remember by many chemicals are used in food	Remember the different groups and think about which group the elements are in	Experiment and see for myself what happens to the weight or matter after a chemical reaction	Remember the area that has the least height is called the transition elements. Non metals are to the right of the step ladder. The whole line of the right end of the periodic table - the far right row, are gases that don't react. Mercury & Bromine are liquids at room temperature.	*Absent*	*Absent*
Cro (f)	Photosynthesis	No response	Do the prac.	*Absent*	Write them in my book	Write stuff in my book
Sev (m)	Remember the 2 types of reactions - exothermic and endothermic	No response	Listen to instruction	Read chapter 1 again	The basic word-poly	*Absent*
Dob (f)	Try to practise and memorise them	Practise and memorise it	Practice/memorise	Practice them, learn them, draw them and try to memorise them	*Absent*	*Absent*

(m) = male: (f) = female

Table 4: Examples of Year 9 students' statements about "Relate" on the learning protocols on three occasions (retaining students' own words)

What do you already know about this topic?			
Student ID	*26/08/2008 (chemical reactions)*	*15/09/08 (polymers)*	*17/09/08 (natural polymers)*
Tsm (f)	*Some of the symbols of the elements*	*Absent*	*Absent*
Cci (m)	*No response*	*Nothing*	*Polymers*
Aba (m)	*Absent*	*No response*	*I don't know anything that relates to this*
Sma (m)	*Enough*	*Absent*	*Absent*
Abu (m)	*..the signs of a chemical reaction; things that affect the rate of chemical reactions*	*Nothing - never heard of it*	*Polymers are long chains of molecules*
Lga (m)	*Periodic table; chemical reactions*	*Absent*	*Cotton and wool, amino acids, starch*
Jth (m)	*Different chemical reactions and the elements from the periodic table*	*Absent*	*Absent*
Pmo (m)	*Absent*	*Absent*	*Absent*
Tlo (f)	*The periodic table*	*Carbon chains*	*Sugar and carbs are the same thing*
Dco (f)	*No response*	*Carbon chains*	*Sugar and carbohydrates are the same thing*
Shu (f)	*Things like heat & cold affect the rate of chemical reactions*	*Absent*	*Absent*
Cro (f)	*Absent*	*Carbon chains*	*Polymera=made up of monomers sugar and carbohydrates are the same*
Sev (m)	*Things affecting rate of chemical reaction*	*Many everyday utensils and commodities are made of polymers*	*Absent*
Dob (f)	*Some chemical reactions and some elements on the periodic table*	*Absent*	*Absent*

Table 5: Profiles of Year 9 students' use of diagrams and concept maps on four occasions

Student ID	pre-test 21/05/08	test 2/06/08	test 23/09/08	test 29/10/08
Tsm (f)	no	no	no	no
Cci (m)	no	*Absent*	*Absent*	yes
Aba (m)	no	yes	yes	yes
Sma (m)	no	no	yes	yes
Abu (m)	no	no	*Absent*	yes
Lga (m)	no	no	yes	yes
Jth (m)	no	no	yes	no
Pmo (m)	no	no	yes	yes
Tlo (f)	no	yes	yes	yes
Dco (f)	no	yes	yes	yes
Shu (f)	no	yes	yes	*Absent*
Cro (f)	no	yes	no	yes
Ecl (f)	no	yes	*Transferred*	*Transferred*
Sev (m)	no	yes	yes	yes
Dob (f)	no	*Absent*	no	no

yes = generated a concept map or diagram

no = did not generate a concept map or diagram

Table 6: Examples of Year 9 science students' responses to "check" on the learning protocols on three occasions

Is there anything about this topic that you don't understand or are not clear about? What question could/should I ask about this topic?

Student ID	28/08/2008 (chemical reactions)	15/09/08 (polymers)	17/09/08 (natural polymers)
Tsm (f)	No response	*Absent*	*Absent*
Cci (m)	I don't know	No response	No response
Aba (m)	*Absent*	No response	No response
Sma (m)	No	*Absent*	*Absent*
Abu (m)	No	Can you not give us a test on this? Are there any other things that are polymers?	Can you give me a list of all the different polymers?
Lga (m)	Periodic table parts	*Absent*	No response
Jth (m)	Most of it	*Absent*	*Absent*
Pmo (m)	*Absent*	*Absent*	*Absent*
Tlo (f)	I'm pretty understanding	No response	Is everyone a polymer? Do dogs have hair or fur?
Dco (m)	No response	What is a polymer?	No response
Shu (f)	The answers to the chemical reactions part of the test - we did that a while ago and I don't have a good memory	*Absent*	*Absent*
Cro (f)	*Absent*	No response	No response
Sev (m)	The elements	No response	No response
Dob (f)	How to spell some elements, where the elements go on the periodic table	*Absent*	*Absent*

Shading: Student feedback that has the potential to generate revised teaching plans

Table 7: Conceptual themes and student generated examples (retaining students' own words) from the Year 11 psychology students' learning protocol statements

Conceptual themes	*Student generated examples*	*Student generated examples*
	Prior to learning protocols interventions	***During learning protocols interventions***
Select	*Paying attention so it made sense*	*Paying attention so it made sense*
	Listening	*Listening*
		Identifying topics to remember
Relate *(simple transformation)*	*Thinking on it as it is taught*	*Thinking on it as it is taught*
	Reading, read text	*Reading, read text*
	Going over what's in the book	*Going over what's in the book*
	Writing down. It's in my book	*Writing down. It's in my book*
	Writing notes	*Writing notes*
	Writing definitions	*Writing definitions*
	Reading notes	*Reading notes*
		Putting it into my book
		View video clips
		Proof reading
		Processing
		Rehearsing
Relate *(complex transformation)*	*Make words out of letters so I could remember them*	*Make words out of letters so I could remember them*
		Elaborative rehearsal
		Write down in my own words
		Making a practical
		Class discussion
		Researching definitions
		Re-arranging information
		Creating retrieval cues
Organise *(encoding)*	*Memorising a few things*	*Memorising a few things*
	Summarise each definition myself	*Summarise each definition myself*
		Diagrams (to link ideas)
		Concept maps
		Grouping, chunking
Organise *(using*	*Reading over what I have written*	*Reading over what I have written*

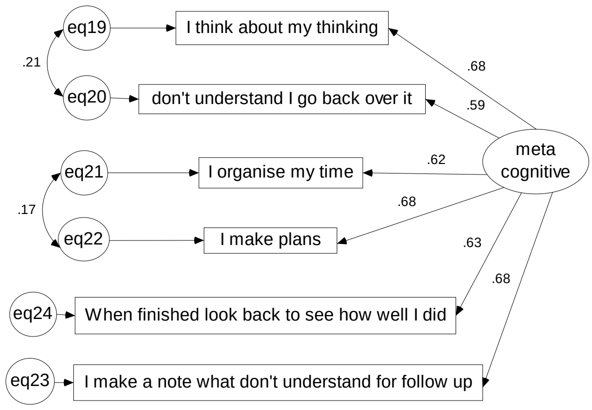
and retrieving)		
	Recalling	*Recalling*
	Review, revise	*Review, revise*
	Rewriting what I have written	*Rewriting what I have written*
	Re-wrote until I knew what it meant	*Re-wrote until I knew what it meant*
		Looking over previous work
		Reading notes, going over notes
		Doing test questions
		Performing homework tasks to reinforce learning
		Picture where I was in the situation
Check	*Answering questions*	*Answering questions*
		Reflecting on notes
		Reflecting on new information
		Rethinking what was discussed
		Ask for help when I don't understand
		Organising the homework in my diary

APPENDIX A

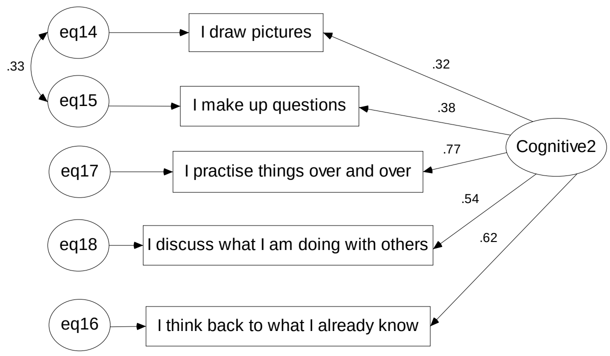
Confirmatory Factor Analysis (CFA) of the Cognitive and Metacognitive Factors

Missing values were replaced using normal Expectation-Maximisation in PASW 17.0 Split-half analysis provided support for each of the one factor congeneric models. CFA of the Cognitive factor suggested that two items, q.14 & q.15 (i.e. “I draw pictures or diagrams to help me understand this subject” and “I make up questions that I try to answer about this subject”) had poor loadings on the latent factor and would probably be reflective of another sub-factor. While a re-specification of the model with q.14 & q.15 loading separately onto a separate factor suggested that this would be a better model, the reliability of each of the two sub- factors was inadequate for further statistical analyses using these factors as two composite variables (two-item factor Coefficient $H = 0.60$; three-item factor Coefficient $H = 0.71$). A decision was made to keep the more reliable (Coefficient $H = 0.76$) 5-item cognitive factor for use in further statistical analyses. Each of the composite variables were calculated using factor score coefficients and rescaling them to sum to 1 before using them to weight participant responses for each item. Weighted item responses were then summed accordingly to obtain a composite factor score for use in subsequent analyses. Further details about the CFA can be obtained from the authors.

Confirmatory Factor Analysis of Metacognitive items

I think about my thinking, to check if I understand the ideas in this subject. When I don't understand something in this subject I go back over it again. I organise my time to manage my learning in this subject. I make plans for how to do the activities in this subject. I make a note of things that I don't understand very well in this subject, so that I can follow them up. When I have finished an activity in this subject I look back to see how well I did.	 Coefficient *H* = .82 (adequate reliability) Chi-square (7, 1388) = 23.9, $p < .0012$ CFI = .991, TLI = .981, RMSEA = .042

Confirmatory Factor Analysis of Cognitive items

I draw pictures or diagrams to help me understand this subject. I make up questions that I try to answer about this subject. When I am learning something new in this subject, I think back to what I already know about it. I practise things over and over until I know them well in this subject. I discuss what I am doing in this subject with others.	 Coefficient H = .74 (adequate reliability) Chi-square (4, 1388) = 8.6, $p < .07$ CFI = .995, TLI = .989, RMSEA = .029