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Variations to Stimulated Recall Protocols to Enhance Student Reflection: I did, I saw, I remembered.

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Abstract

The project, Mental Models and Robotics and Middle Schooling, was an empirical qualitative study centred within information processing theory and linked with the introspection mediating process tracing paradigm. The study involved students and their teacher in a socio-economically diverse urban primary school and aimed to establish how the identification of participants' mental models can assist in the authentic assessment of learning through a richer understanding of the cognitive development taking place in a technology based learning experience. The strict protocols of Stimulated Recall methodology were used to externalise participants' 'in-action' mental models, using the opening question 'What were you thinking?' The use of this rigid questioning technique elicited insufficient responses from the students. An additional opening question, 'What were you doing?' was added in the second episode of Stimulated Recall prior to the question, 'What were you thinking while you were doing that?' This change elicited increased quantity and quality of responses because students were able to link their thoughts and feelings with associated actions and reactions. Richer mental models of procedural knowledge but more crucially, conceptual knowledge, were evident in the recall of journaling activities. Social construction mental models were also richer as students more willingly linked thought to action.

Choreographing the Dance

Dancer and choreographer Martha Graham (cited in Cousineau, 2000) wrote about a unique 'life force' or 'vitality' that each of us possess that we translate into action. This 'quickening' should flow without comparison or evaluation or it will be lost. She wrote of the need to keep our 'channel open' and to be aware of the urges that directly motivate us: "a blessed unrest that keeps us marching and makes us more alive" (p. 54). How is this reference to the vitality of life forces and open channels relevant to the use of stimulated recall methodology to determine the mental models held by students and teachers?

Cognitive research seeks to probe beyond the external, somatic displays of students to observe what takes place in their minds. A variety of methodologies are available to open the channels that reveal the unique 'life forces' that each participant brings to a study. Introspection methodologies, including stimulated recall, assume that it is possible to glimpse the consciousness in the same way that classroom observation can record the physical (Gass & Mackey, 2000). Research participants are not static; they 'march' on with a 'blessed unrest' that is both physical and mental. One only needs to spend a short period of time with young learners and their teachers to realise the physical and mental gymnastics required of them during a regular school day. What stimulated recall, as part of the introspection mediating process tracing paradigm, allows researchers to do is to track part of the physical and mental march for a short time by encouraging participants to relive some action by using cues or

stimuli that were present at the time of that physical, social, and/or cognitive action (Bloom, 1954; Barrows, 2000; Henderson & Tallman, 2006).

The Vitality of Mental Models

Mental model theory has been used in cognitive research since 1943 when Craik proposed them as an explanation for human thought processes. Early systems design recognised that users have a mental model of a system created by a designer; a dynamic representation of the reality of the system. This early work was taken up by others including Johnson-Laird (1983) who saw mental model theory as an approach to use in pure research into text comprehension and reasoning. He and others (Gentner 1998; Barker, van Schaik, & Hudson, 1998; Schwartz and Glack, 1996; Carroll & Olson, 1988) have confirmed that mental models exist in order to understand the phenomena they represent in the real world.

Real world phenomena are dynamic and, much as we need to be aware of an ever-changing landscape, we also, as Graham wrote, have to be aware of our individual motivations and abilities (in Cousineau, 2000) to interact with this landscape. Mental models have to be individually functional as they are being constructed (Norman, 1983) as well as helpful in facilitating the investigation of alternatives as a learner explores a problem or encounters new real world phenomena (Carley & Palmquist, 1992; Renk, Branch & Chang, 1994). Because our interactions with the world and motivational urges to engage are personal and idiosyncratic, so are our mental models (Greca & Moreira, 2000). We are motivated by different needs and desires and mental models that are functional for one may be unworkable for another. Regardless of individualisation, one of the roles of mental models is their power to inform learners of the variety of sensible actions that are possible during an interaction (Bibby, 1992). While learners are interacting with any phenomenon, they are constantly running various mental models (Johnson-Laird, Oakhill, & Bull, 1986; Norman; 1983; Payne, 1991).

The act of running a mental model and the subsequent reflection on its effectiveness is associated with a learner's meta-ability (Anderson, Howe & Tolmie, 1996; Haycock & Fowler, 1996; Johnson-Laird et al., 1986) and their capacity to utilise short-term or working memory effectively (Anderson et al., 1996; Johnson-Laird et al., 1986; Newton, 1996). The ability to access working memory, where mental models are created and manipulated (Henderson & Tallman, 2006), is important for making inferences and relating propositions in problem-solving situations. Johnson-Laird et al. (1986) also found that young children often experienced limitations in retrieving the necessary long-term memories, where mental models are stored, to relate with a domain. Therefore, mental model creation and manipulation may be limited if the relevant long-term or working-memory is not accessed effectively.

The recognition of the effectiveness of running mental models supported the earlier theory of development by Piaget (1972) where he discussed the inability of young children to negotiate and manipulate conceptual models prior to creating their own. Anderson et at. (1996) found children's process of negotiating the manipulation of conceptual models prior to running their own mental models was difficult due to their limited working memory. Therefore, the effective running of a mental model to improve cognition may be reliant upon scaffolded activities by teachers who present conceptual models to help learners build their own mental models (Mayer, 1989).

Conscientious teachers act as the more capable other (Vygotsky, 1978) and attempt to create an organised learning environment with scaffolded support for students. The effectiveness of these environments depends on the students' ability to integrate new knowledge and concepts to ones that has been developed in prior experiences; that is to construct effective mental models. Meaningful learning in a classroom is diffused constructively in an adaptive process where the learners' existing mental models, albeit incomplete, idiosyncratic, and disorganised, can be modified through individual interactions (Glaserfeld, 1993; Jonassen, 1995) resulting in some meaningful action.

So, while mental models are individually constructed (Greca & Moreira, 2000), in much the same way as Piaget (1972) proposed individual conceptual understanding (Anderson et al., 1996), they also derive social meaning through their intersection or relationships with other people's mental models (Carley & Palmquist, 1992). Vygotsky (1978) described the socially constructive nature of experiences and their effect in creating individual conceptions. It is this social nature of learning within the schools that often focuses teacher attention on the observable diffusion of learning evident in classrooms.

The "exteriorisation" (Barker et al., 1998) of mental models occurs when a learner's mental models are triggered by some stimuli (Barker et al., 1998) or through interaction with a domain system (Norman, 1983; Carroll & Olson, 1988; van der Veer, 1990) such as robotics or computer software. This interaction results in some physical action or inferred performance (Jonassen, 1995) which can be observed. Mental models are internal structures (Johnson-Laird, 1983; Norman, 1983; Renk et al., 1994), particular to the user (Greca & Moreira, 2000) and can be unstable, inaccurate, or incomplete (di Sessa, 1986; Gentner & Gentner, 1983; Norman, 1983) and therefore difficult to observe in the same way that physical performance can be documented. Mental models are inherently epistemic (Norman, 1983), thereby forming the basis of how we express what we know. But they are also personal and not easily known to others or even comprehended openly by the user (Jonassen, 1995). The study of mental models is complex and, therefore, requires a variety of methods, including stimulated recall, to exteriorise them for greater understanding.

Opening the Channel

Stimulated recall is an introspective research technique. It was first used by Bloom (1954) as a method to study the recall reliability of students after a classroom event. It has been used effectively in many studies (Erickson & Mohatt, 1977; Hample, 1984; Benoit, 1995) including those into mental models where 'in-action' mental models and decision-making strategies held by students and teachers during instructional activities were studied (Henderson & Tallman, 2006; Gass & Mackey, 2000; Meade & McMeniman, 1992). Stimulated recall is often used with other methodologies to triangulate data for accuracy and authenticity. Its particular aim is to reveal cognitive processes that are not usually evident by other methodologies, including direct observation (Gass & Mackey, 2000). Gass and Mackey (2000) offered three reasons for the use of stimulated recall methodology and the relationship between these reasons and mental model theory is illustrated in Figure 1.

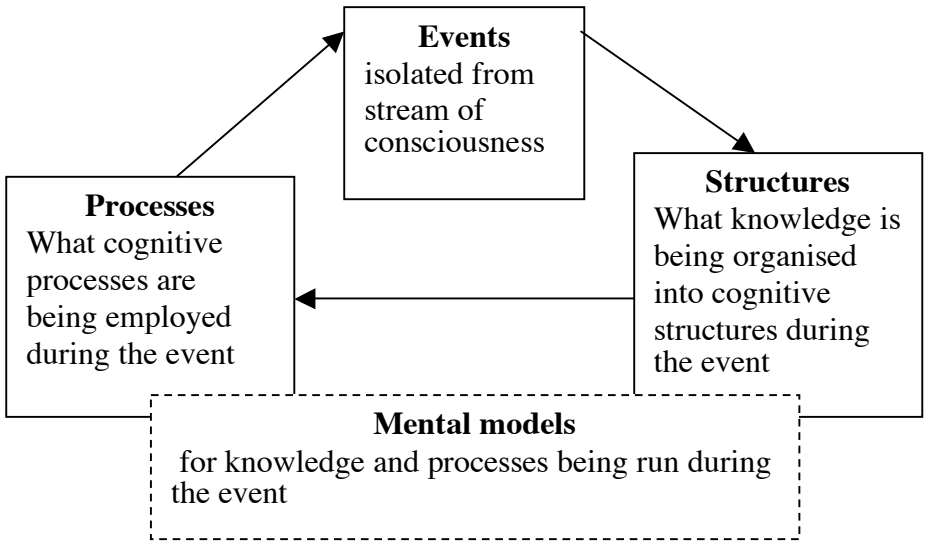

Figure 1. Relationship between reasons for undertaking stimulated recall methods and mental model theory.

The information being accessed by stimulated recall is the conscious thoughts of the students during a previous activity. The recall of these conscious thoughts, stimulated by the video of that activity and research question, is linked to the events that are observable. The use of the video provides a visual and aural stimulus because it is a documentation of the participant 'in-action'. This is particularly necessary when working with students because it can trigger memory cues of their participation in a recorded event. Gass and Mackey (2000) used stimulated recall to exteriorise cognitive structures and process used by students in second language learning situations as shown in Figure 1. This method of introspective research was used by Henderson and Tallman (2006) to determine the mental models of teacher-librarians and students using a computer information database. In both research projects the recorded actions were observable, while their cognitive structures, processes, and mental models, inherently epistemic, were more difficult to define without some verbalisation or exteriorisation. The replay of the actions undertaken at any given point in the previous activities triggered recall of conscious thoughts and associated cognitive structures, processes, and mental models of decision making and problem-solving used in the interaction.

Setting the Scene

The validity and reliability of responses given in stimulated recall can be maximised by adhering to strict protocols such as the use of non-directive questioning, immediacy of interview after the recorded episode, and the initiation of pauses in the video (Gass & Mackey, 2000; Henderson & Tallman, 2006). Questions such as, "What were you thinking here/at this point/right then?" (Gass & Mackey, 2000; p.154) should be used to prompt participant recall. A response of 'don't remember/know' or 'can't remember' may be given and this should be accepted by the researcher without further "fishing" (Gass & Mackey; 2000; p.154) for responses. Maintaining a non-directive questioning response can be difficult as an interviewer may unknowingly put the participant in the position where they are trying to meet unstated expectations of giving an answer. Participants may provide 'here and now' responses created from their understanding of what they believe they should be saying (Nisbett & Wilson, 1977a). Patience is required, particularly with young participants who want to please adults with what they might like to hear.

The instructions given to participants prior to the video replay are important as it is here that they are invited to pause the video at places where specific thoughts are recalled.The initiation of the pauses in the replay of the video can maximise the validity and reliability of responses in stimulated recall interviews. Henderson and Tallman (2006) found when working with teacher-librarians that they had a "greater likelihood of obtaining a more thorough recall of what the participants had been thinking" (p.79) if both the participant and the interviewer pause the video at appropriate places. Researchers can pause the video playback if they are looking for thoughts on specific interactions containing "implicit negative feedback" (Gass & Mackey; 2000, p.53) such as a teacher's facial expression to a student response or particular mental models (Henderson & Tallman, 2006) such as procedural or conceptual mental models. Participant pauses may uncover unanticipated yet enlightening data that may otherwise be missed if participants are not given the opportunity to initiate them. A combination of both researcher- and participant-initiated pauses was used in both of the stimulated recall sessions outlined in this paper to maximise the opportunity for the exteriorisation of 'in action' mental models.

The New Script

The strict protocols of this methodology are essential to maximise the validity and reliability of data. However, a variation to the protocols was seen to be necessary with this group of primary school students involved in a robotics class after the first round of stimulated recall interviews elicited insufficient responses. Students' recall was enhanced, yet remained uncontaminated, with the inclusion of an opening question at each pause in the video. The additional question, "What were you doing?" encouraged the students to reconstruct events prior to answering the question "What were you thinking/feeling then?" As previously mentioned Bloom's (1954) early work with stimulated recall linked the recall of a student's 'conscious thought' with events that were observable and therefore able to be viewed and relived. However, what has been given far less significance is Bloom's (1954) emphasis of using a variety of cues or stimuli to relive the original situation to ensure the focus remained on the actual thoughts of the participants during an event. To stimulate or assist the recall of these thoughts, verbalisation of the event following the replay of the event should strengthen the coincidental consciousness required to 'exteriorise' the mental model verbally. This new script was found to be very effective in prompting recall of thoughts and feelings.

The Performance: Act 1

Martha Graham choreographed more than 160 dance plays and used an extensive variety of themes to express human emotions. Her belief in herself and awareness of the urges that motivated her contributed to this great volume of work which had a profound effect on how modern dance was visually presented. A willingness to engage with any medium and the ability to exteriorise our thoughts throughout such engagements increase our self awareness – our meta-ability. Seeing what we have done and re-stating those actions help to replay the events and evoke a sense of self – a powerful understanding of why we do what we do. Such was the case with the second series of stimulated recall interviews. The participants, working in pairs, were given the challenge of a programming and building exercise that was part of the preliminary activities in the Mindstorms© program. The subsequent interview, with changes to the protocol, enabled them to better recall the thoughts and feelings that motivated them throughout the engagement.

Counting Our Steps

The additional question 'What were you doing?' asked prior to the benchmark stimulated recall interview question, 'What were you thinking/feeling?' brought about an increase in the quantity of the 'useable responses' from the students. 'Useable responses' refer to the responses that provide the introspective "there and then" thoughts/feelings that occurred during the actual event rather than a hindsight report of the event or a reflective "here and now" explanation of what they were doing that occurred to them during the interview (Henderson & Tallman, 2006; p. 77). Figure 2 shows the change in useable responses from the four student participants in the two sessions.

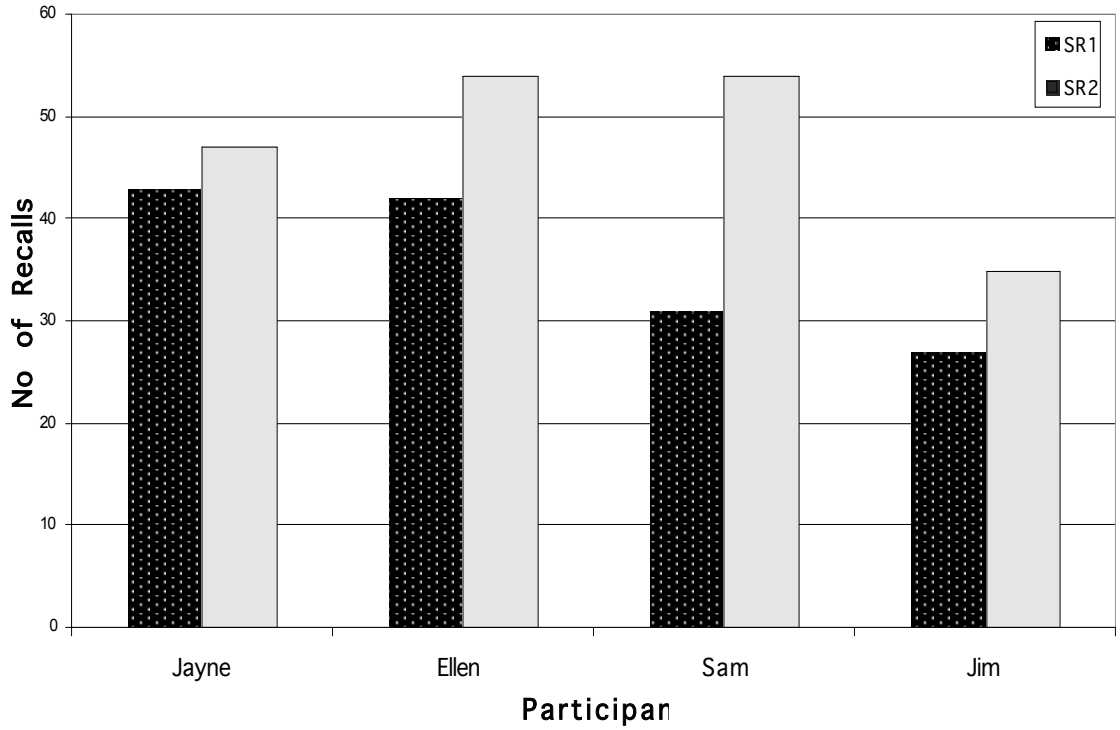

Figure 2. Stimulated recall useable responses.

While all students gave more useable responses during the second stimulated recall session, the increases are noticeably different amongst participants. This difference was also observable in the number of 'no thoughts' or 'can't remember' responses given by the students between the sessions as shown in Figure 3.

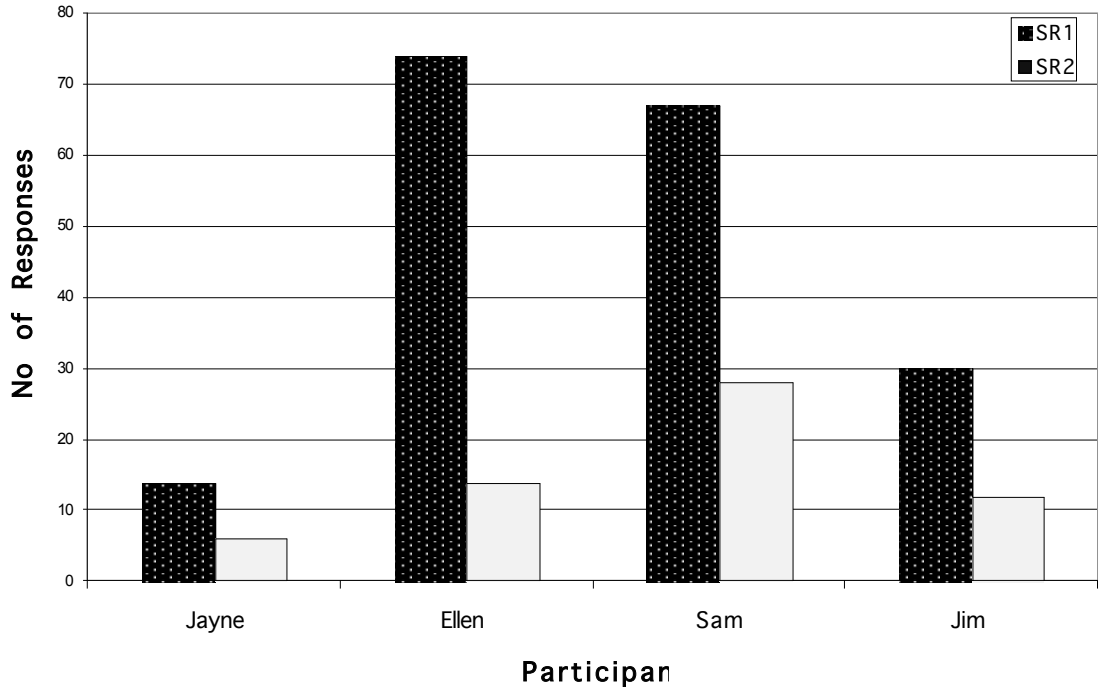

Figure 3. Stimulated recall no thoughts responses.

Jayne showed the least increase in useable responses (9%) (figure 2) and the least decrease in no thoughts responses, although her 57% (figure 3) decrease in the second stimulated recall interview is substantial. Of all the participants, she was the most verbose, often adding explanations and observations to her recalled thoughts. Jayne's sense-making disposition and propensity to create explanations without prompting reflected the central idea of Dennett's (1987) work where he 'argued that we tend to understand activities as if they are a product of some meaning-producing entity' (cited in Gass & Mackey, 2000; p.5). Dennett (1987) also believed that we can only report on that which we are conscious. Jayne's recalled thoughts with explanations and observations are her conscious thoughts and indicate her willingness to provide as full a picture of what was happening as she could.

Sam's 43% (figure 2) increase in useable responses was the greatest change in this section due to the change to the protocol which enabled him to verbalise his actions prior to providing his thoughts. His successful completion of the activity, with his partner Jim, promoted self-confidence which may also account, in part, for this increase in useable responses. Jim's increase of 23% (figure 2) is less than his partner's, but when considered with his low incidence of no thought responses in both interviews indicates his self-confidence across both interviews with a positive influence of the change in the protocol in the second series. Ellen's 81% (figure 3) decrease in no response is the largest in the no thoughts section and may reflect her engagement with the activities she undertook during the second videoed lesson. She used many problem-solving strategies and was intent on reaching a solution in the second lesson where technical building problems became an issue for her and her partner, Jayne. While she was sorry that they had not achieved their goal for the lesson, she felt that 'we can make it work if we actually try' which exteriorises her problem-solving strategies.

The exteriorisation (Barker et al, 1998) of mental models, discussed earlier, occurs through a stimulus trigger (Barker et al., 1998), such as an interaction with a domain system (Norman, 1983; Carroll & Olson, 1988; van der Veer, 1990). In the stimulated recall sessions, the

exteriorised mental models (actions and interactions) of the participants from the previous engagement with the robotics material were being replayed through the video. This visual exteriorisation of their mental models provided an opportunity to bring back into working memory the thoughts and feelings during that engagement. The personal, epistemic nature of mental models indicates that, while each of the participants will have some recall of their previous thoughts, the very nature of how they express what they know or remember will vary. This is clearly indicated in differences between participants during the sessions and across the sessions.

While the students displayed positive attitudes during the sessions, they often exhibited some frustration if they found themselves not remembering thoughts or feelings from the activity. A constant 'can't remember' response to pauses or prompts may contribute to students' sense of frustration with the interview. It was evident that some frustration was creeping in at times for the participants who could not recall specific thoughts when prompted particularly from Ellen who stated after several prompts, 'Still no thoughts'. The priori protocol, 'What were you doing then?' enabled them to return to the event and to replay the running of their mental models. The subsequent reflection about these actions and the mental models being run is linked with their level of metacognition (Anderson et al., 1996; Haycock & Fowler, 1996; Johnson-Laird et al., 1986) or their capacity to engage in quality thinking. What may be of interest is the relationship between the ability to recall thoughts from an interaction with a domain, such as robotics, and a participant's meta-ability. Their capability and experience of thinking about their own thinking during an activity may have some relation to their recall of thoughts at a later date.

This relationship may have an impact on the success of stimulated recall sessions. It is a tenuous dance we participate in when we interview others. It is a creative act, albeit with protocols and regulation. Participants share their thoughts and feelings openly and willingly. It may not be, as Graham writes, their primary business to determine how good or valuable they are; nor how they compare with the thoughts and feelings of others. However, we must accept that some of the responses participants offer will be affected by how they see themselves - their personal view of themselves and their meta-ability.

The Performance: Act 2

The responses provided in the second sessions of stimulated recall were coded into 'action', 'here and now' and 'there and then' (Henderson & Tallman, 2006; p.77) categories just as they were in the initial session. There were, overall, a greater number of responses to the pauses in the video due to the participants' willingness to describe their actions prior to verbalising what they were thinking/feeling. Subsequent analysis of the interviews revealed a greater number of 'useable responses' which were compared for content to those provided in the first session. The quality of the types of thinking was the major improvement seen in the second series of interviews. Students were able to focus more readily on their actions and interactions and verbalise their thoughts and feelings more clearly. They were more relaxed during the interviews due to their previous experience, which may have had some impact on their ability to provide recalled thoughts and feelings. Gass and Mackey (2000) recommended minimal training for participants; enough so that they can carry out the instructions to respond but not "cued into experimental goals or unnecessary information" (p.54).

Rehearsing and Reflecting

The students wrote in their journals before and after each robotics lessons. The journal entries were given teacher-established categories to record the series of activities undertaken. The first entry was to give their goal for that lesson while the second was done following the engagement and described what they had achieved. They also were required to reflect on what they had learned. The entries below show the difference in responses between session one [SR1] and session two [SR2]. Sam's responses are shown below in Figure 4.

SR1	SR2
Uh, just to write down what if we, I think it was, if we succeeded with our goal. No, I was just wondering if I had to get a pencil. Um, yes just thinking about what the other people had thought.	I was trying to find the page. But I hadn't been in the robotics lab since my last entry and I hadn't been in it after that … after the one yesterday as well. *So, I hadn't achieved anything with that.* Mostly what I was thinking about what I was going to write. *And that would've been to get up a couple of levels.* [I was feeling] Hopeful

Italics: Here and Now response; Underlined: Action description; Regular font: There and Then response

Figure 4. Sam's responses to pauses during journal writing

Sam's first session response focused on writing implements and other people's responses. In the second session he was able to describe his actions and give some commentary on what he was doing and why. His subsequent recalled thought, 'Mostly what I was going to write' (figure 4) provides a glimpse of his thought processes at the time and indicates his mental model of journal writing: planning during that part of the lesson. Sam's subsequent 'feeling' of 'hopeful' (figure 4) shows a mental model of prediction being run while he is positioning himself prior to the experience. In this instance, the additional explanation seemed to not overload cognition (Ericsson & Simon, 1993) and interfere negatively with recall; rather, it was enhanced.

Acting

The number of responses to pauses in the video were perhaps most indicative of the incidence of procedural knowledge the students used throughout the lessons. Jayne, the most verbose participant, would explain what she was doing in the first session without prompts to do so. The inclusion of the new question gave her the green light to expand on this already established practice. Her responses to pauses in the video where the students were working on the programming and building are shown in Figure 5.

SR1	SR2
Yeah, I just said to Ellen, I don't know what to do, I just don't understand. I was thinking that I'd probably have to get the teacher because I really didn't understand, then the teacher came.	Going through the steps. To see if it would work. Seeing it they were the same and if we needed to put anything on it or take anything away. I thought it was quite complicated because it kept showing us stuff that we didn't have so we just took if off and built it again.

Italics: Here and Now response; Underlined: Action description; Regular font: There and Then response

Figure 5. Jayne's responses to pauses during programming and building

The use of 'non-directive' prompts in both interviews increases the likelihood of reliability and accuracy of recall (Henderson & Tallman, 2006; p.78). Jayne explained her actions in both, as was usual for her. The SR1 response indicates her mental model of procedural

knowledge and her way of proceeding when faced with difficulties; waiting for teacher help. In SR2 she revealed more depth to this mental model by explaining 'it kept showing us stuff' (figure 5) as the reason she thought the procedure of programming was complicated. She was able to explain her actions at the time and verbalised her mental model of comparison: artefact to diagram, a metacognitive strategy that enabled her to exteriorise her degree of knowledge and understanding (Norman, 1983) and how she would subsequently solve the problem with her partner.

Setting the Stage

The students developed conceptual mental models of the relationship between different components of the robotics system: the computer program, infra-red and robot. While Howe and Tolmie (1996) found the process of manipulating conceptual mental models prior to running them was often difficult for children, the following responses from Jim show that his conceptual mental model of this relationship is being modified through individual interactions with himself, his teacher and partner (Glaserfeld, 1993; Jonassen, 1995).

SR1	SR2
Don't touch it. It's supposed to stay there.	She's [teacher] asking us … we told her that it wasn't working. And then, Sam kept skipping all these things and then she started, "Why? Why'd you do that?" You'd better not do that. It might not work. Oh, I know what I'm doing now. I've done it before. *Yes. And that's what he was saying at the time too.*

Italics: Here and Now response; Underlined: Action description; Regular font: There and Then response

Figure 6. Jim's responses to pauses during running the RCX

Jim's SR1 responses show his mental model of robot placement as his partner, Sam, and he were waiting for the program to download through the infra-red to the robot. His verbalisation indicates his conceptual knowledge of the relationship of the three components of the system. He gives his thoughts 'Don't touch it. It's supposed to stay there' (figure 6) in response to Sam's attempt to move the robot. The SR2 response is an indication of how his mental model of programming is being modified through the interaction with Sam as he programmed (incorrectly, as it turned out) and the teacher's response to this. The prompt, 'What were you doing?' enabled Jim to give an explanation of the events at the time, prior to giving his actual thoughts as the events were happening. Jim's conceptual mental model of programming/cause and effect is evident in his recalled response 'You'd better not do that. It might not work' (figure 6) so he has linked Sam's 'skipping' through the program with lack of success.

The Cast

From a sociology point of view, much of our knowledge is socially rather than individually constructed (Berger & Luckman, 1967). While students are interacting with domains, such as robotics, and with others during the interaction, they are running several mental models. This simultaneous running of mental models informs the student of the variety of actions and interactions that are possible (Bibby, 1992). The students in this study were not paired based on friendship and were gender-homogenous. However, students at this age have been 'socialised' to work in various group-types for classroom activities so they would have existing mental models for working in groups. Just as the confidence to use a strategy for locating items rather than remembering every menu item on a software program, are

'embedded' in our mental models (Henderson & Tallman, 2006; p.46) so are the strategies for working with others. A student's meta-ability informs them of their 'deficits' when interacting with a domain, and the opportunity to work with another within this domain may encourage them to create 'fragmented' mental models due to the perceived reduction in effort required. Henderson and Tallman (2006) argue the case of the purposeful fragmentation of mental models created when working with specific software packages.

An example of a social interaction and its interpretation by two students was evident in SR2 and uncovered as a result of the addition to the protocol. Figure 7 shows both Ellen and Jayne's responses to an interaction where the robot was being programmed.

Ellen	Jayne
She was like showing me where to click and everything. That she didn't really need to do that, 'cos [sic] *like, there was a running arrow pointing to there in the computer*. I felt okay.	I kept pointing to the screen because she kept waiting for ages before clicking on it and *I just usually click it as soon as it says it*. Um, ah, that she's a bit slow. She shouldn't do that.

Italics: Here and Now response; Underlined: Action description; Regular font: There and Then response

Figure 7. Ellen and Jayne's responses to pauses during programming

Jayne was comparing Ellen's speed at programming with her own which indicates her mental model for programming was functional. Ellen was not having any difficulty and felt that this assistance was unnecessary due to her own mental model for programming with her understanding of the program and its inclusion of sequential arrows. She was not unduly fazed by Jayne's impatience which was evident with her recalled thought 'she shouldn't do that' (figure 7) indicating that she felt that Ellen was being intentionally slow. At the next prompt Jayne made the observation that Ellen 'went faster' and her subsequent recalled thought 'I felt that's good because we'd probably get it done in time' (figure 7) puts her obvious impatience into some perspective due to the time limitation on the activity and their lack of success to this point.

The physical and mental march of the participants in this study was tracked for a short time using the stimulated recall methodology with the additional protocol. Reliving their actions through visual stimuli and verbalising these actions prior to recalling thoughts proved beneficial in opening this channel of observation even wider. The next section discusses the implications of using this enhanced stimulated recall protocol with children

I Did, I Saw, I Remembered

The theory behind stimulated recall is dependent upon introspective information processing where recall can be enhanced by the use of prompts such as videos (Gass & Mackey, 2000). Bloom (1954) believed that the strength of the stimulated recall procedure could be enhanced by providing a large number of cues from the original situation. The primary purpose of any cue or stimulus is to "reactivate or refresh recollection of cognitive processes so that they can be accurately recalled and verbalised" (Gass & Mackey, 2000, p. 53). The forte of this study was the constancy of the variables: context, participants, and setting. The research variable was the additional question in the stimulated recall interview protocol in the second series [SR2]. The significance of this study to inform stimulated recall methodology is the comparison of the responses from two series of interviews one with and one without the research variable.

The question, "What were you doing?" provided an additional stimulus to the video cue to prompt the student to revisit the event in their head before responding to the question, "What were you thinking/feeling while you were doing that?" The quantitative change in responses indicated that the addition to the questioning protocol resulted in a greater number of useable responses (Figure 2) and a decrease in the number of no thoughts responses (Figure 3). The opportunity to verbally exteriorise actions of an event prior to recalling thoughts and feelings at that time also enhanced the qualitative nature of the responses for all participants. Figures 4 to 7 show segments of the interview transcripts where the students were better able to recall thoughts and feelings following the viewing of the video and the verbalisation of action.

Another contribution to stimulated recall methodology is the recognition of the significance of the relationship of the participants' meta-ability to their ability to access short-term memory for retrieval of thoughts and feelings. Participants who were experienced at thinking about their own thought processes appear to have greater recall. The implication for research using stimulated recall methodology is that young children may be incapable of providing the thoughts and feelings from an interaction if they have had little experience in metacognition. There may be a limitation on age of participants for which stimulated recall methods are effective.

It may be beneficial to investigate the learning experiences of young children before implementing a research protocol. The students in this study were aged ten to eleven years when the stimulated recall interviews were conducted. They had been exposed to constructivist pedagogy for at least eighteen months so were familiar with thinking about their own thought processes during problem solving situations. They had also been exposed to negotiated assessment practices where their reflections on their learning experiences contributed to the overall picture of cognitive development used for reporting. Robotics was new but the problem-solving strategies they were using to negotiate and evaluate their experiences were not. While they were still somewhat reliant on teacher assistance when encountering problems, they implemented strategies to predict and solve problems.

The mental march of the students in this research project was tracked for a short period of time. Their vitality and enthusiasm for learning was evident from their interactions with the domain, each other, and this author. Stimulated recall methodology with the additional questioning protocol allowed the channel of introspection to be opened wider thereby ensuring that the choreography of the dance contributed effectively to a successful performance.

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