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ORIGINAL ARTICLE

Aspects of pedagogy supporting metacognition and self-regulation in mathematical learning of young children: evidence from an observational study

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Abstract This article reports on evidence collected within a UK study concerning metacognition in young children in the 3–5-year age range within mathematical contexts. Young children were video-recorded on a number of occasions in the naturalistic context of their Foundation Stage settings and classrooms, including both nursery and reception classes. The children were engaged in mathematical activities designed by practitioners to facilitate metacognitive processes. Metacognitive 'events' were identified and the children's behaviour was analysed for indications of metacognitive thinking. At the same time, the pedagogical context of the activities, including interventions by adult practitioners, was analysed in relation to the metacognitive opportunities afforded. Findings were that the young children did indeed show evidence, through their talk, and their non-verbal actions, of emergent metacognitive processes, and that the nature and frequency of these processes were influenced by pedagogical aspects of the mathematical activities. In particular, pedagogical interactions which provided children in this age range with emotionally contingent support, which gave them feelings of autonomy and control, which provided them with cognitive challenges and the opportunity to articulate their thinking appeared to provoke and support metacognitive and self-regulatory behaviours.

1 Introduction: metacognition in young children and the development of observational approaches

In early research investigating metacognition with children, the emphasis tended to be on what young children could not do. In what is taken to be one of the very earliest recognitions of the potential significance of the ability to reflect upon our own learning, Piaget (1977) articulated the notion of 'abstracted reflection'. However, he argued that this first emerged in early adolescence during his stage of Formal Operations. Similarly, right from the outset, the seminal work on metamemory by Flavell and colleagues (Flavell, Beech & Chinsky, 1966) developed the key notion of the 'production deficit' which resulted in children under the age of 7 years being incapable of producing a known memory strategy appropriately. In much of the early work, emphasis was placed on the examination of metacognitive knowledge using self-report methodologies. The study by Kreutzer et al. (1975), which found that young children were limited in their ability to report about their own memory abilities and strategies, is typical of this period. This view that metacognition is a sophisticated set of abilities which does not begin to emerge until around the age of 8 years is one that is still widely accepted (Veenman, Van Hout-Wolters & Afflerbach 2006).

There is increasing evidence, however, that these early self-report and laboratory-based methodologies may have seriously underestimated the metacognitive abilities of young children. Certainly, a number of studies have demonstrated the advantages of naturalistic, rather than laboratory-based, studies with young children and of using observation schedules and techniques to evaluate their metacognitive learning. In Istomina's (1975) celebrated study of young children's memory performance, for example, children were involved in a pretence game involving a tea party and were asked to remember items to buy from a store on the other side of the room. In these circumstances, where the children clearly understood the purpose of remembering, they showed evidence of awareness of forgetting, and simple strategies to avoid it, as young

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as 5 years of age. Many other studies have subsequently documented evidence of the early deployment of metacognitive processes by very young children when they are supported by a meaningful context (Blöte, Resing, Mazer & Van Noort, 1999; Deloache, Sugarman & Brown, 1985).

This kind of evidence has also led to a more critical evaluation of assessment instruments used in relation to metacognitive processes, and an increasing recognition of the value of observational data, particularly with young children. In relation to the various kinds of verbal report data most commonly collected in the metacognition literature, interviews, self-report questionnaires, think-aloud protocols, etc., Winne and Perry (2000) have argued that observational data have at least three advantages. First, it records what learners actually do, rather than what they recall or believe they do. Second, it does not depend on the verbal abilities of the participants, which is clearly crucial in studies involving young children. Third, it allows links to be established between learners' behaviours and the context of the task.

This last point is of particular significance when examining children's metacognitive skills in educational contexts. The impact of contextual factors on young children's performance emerges when we look at the research in the area of metacognitive experience, including on-line planning, monitoring, control and evaluation processes. The evidence reviewed by Schneider and Lockl (2002), for example, has indicated that, in comparison to pre-school children, older children can more accurately predict future performance, estimate if they are ready to recall a series of items, and tell if they would be able to recognise the names of items they were not able to retrieve spontaneously. However, the pre-school children were more accurate when the tasks were ecologically valid and meaningful to them. Cultice, Somerville & Wellman (1983) showed that 4 and 5 year olds were able to provide accurate feeling-of-knowing judgements when presented with photographs of adults and children varying in terms of familiarity. Findings related to strategy use have also arrived at the conclusion that very young children can engage in strategic behaviours in the context of meaningful and age-related tasks (Clark, 1978; Deloache, Sugarman & Brown, 1985; Istomina, 1975). In their meta-analysis of studies addressing metamemory–memory performance relations, Schneider and Pressley (1997) found that, depending on the specific requirements of the tasks, correlations between memory monitoring and performance can be substantial even for young pre-school children.

To these points, we would also like to add a fourth advantage, namely, that systematic observation, particularly where it involves video recording, affords the opportunity to identify non-verbal as well as purely verbal behaviour. Increasing evidence is emerging on the role of non-verbal behaviour in the development of young children's conceptual understandings and self-regulatory processes. Studies investigating eye gaze (Ruffman, Garnham, Import & Connolly, 2001) and gesture (Goldin-Meadow, 2002; Pine, Lufkin & Messer, 2004), for example, have suggested that conscious articulation is only a part of the process of children's development in these areas.

As a consequence of these insights, more recent studies have used observations of children's behaviours in naturalistic settings (Boekaerts, 1999; Coltman, 2006; Perry, 1998; Whitebread et al., 2005, 2007a, 2007b) and found evidence of metacognitive (i.e. monitoring and control of cognition) and self-regulatory (i.e. monitoring and control of emotional and motivational behaviours) in much younger children than previously proposed. The material we present in this article in relation to young children's metacognition and self-regulation in mathematical contexts emerged from the Cambridgeshire Independent Learning (C.Ind.Le) project, other findings from which have been reported in these earlier articles. So, e.g., we have established that children in the 3–5-year age range, in the context of early educational contexts, show evidence of emerging metacognitive knowledge, of goal-setting and on-line cognitive, motivational and emotional regulation (Whitebread et al., 2005), that these can be particularly observed in the context of mathematical problem-solving (Coltman, 2006), and in the context of collaborative activities involving peer interaction (Whitebread et al., 2007a). We have also demonstrated that a considerable proportion of this metacognitive and self-regulatory behaviour is evidenced non-verbally (Whitebread et al., 2007b).

2 Pedagogical support for early metacognition

The impact of context on the development of young children's metacognitive behaviour has clear implications for pedagogy. There is now a considerable body of evidence to support the view that children at all levels of ability are able to benefit from explicit instruction in metacognition and self-regulation, including within the domain of mathematics where the encouragement of young children to articulate strategies is a key endeavour (Anghileri 2000). These studies also suggest that a series of features of the instructional framework and setting are likely to increase the effectiveness of the intervention.

Findings from three meta-analyses (Dignath et al., 2008; Hattie et al., 1996; Swanson et al., 1999) of intervention studies have reported similar instructional principles associated with positive intervention outcomes. Hattie et al. (1996), for example, explored 51 studies that reported results of intervention programmes oriented to enhance study skills, self-regulation and motivation. According to this meta-analysis, successful interventions were characterised by (a) strategy instruction embedded in the context of overall self-regulated approaches to learning; (b) the presence of highly supportive learning environments; (c) instruction with a focus on the specific conditions under which strategies are likely to work (when and why); (d) explicit transfer of strategies across areas of the curriculum, and (e) the provision of multiple opportunities for learner activity and reflection.

Swanson et al.'s (1999) review of metacognitive interventions with students with learning disabilities and Dignath et al.'s (2008) meta-analysis of 48 interventions intended to foster self-regulated learning (SRL) amongst primary school children both supported these broad principles. A wide range of studies specifically related to mathematical development, recently reviewed by Carr (2009) and De Corte, Verschaffel and Op't Eynde (2000), have also indicated the significance of pedagogies designed to promote metacognitive processes.

Two points arising from all these works are worthy of emphasis. First, the crucial importance of providing students with the opportunity to reflect on the efficacy of strategies used clearly emerges and has been replicated in numerous experimental studies. Children, in particular, will often show that they are capable of using a strategy and that their performance improves when they do so. However, unless they attribute their improved performance specifically to the use of the strategy, they are unlikely to transfer its use to similar tasks. Fabricius & Hagen (1984), e.g., explored the use of an organisational strategy with 6 and 7 year olds. Following improved performance, some of the children attributed this to the use of the strategy, but others thought they had recalled more because they had looked longer, used their brains more, or slowed down. While 32% of the children in the latter group transferred the use of the strategy to a second recall task, the figure for those who had explicitly recognised the impact of the strategy they had been taught was 99%.

Second, within these meta-analyses and in other reviews of pedagogy in this area (Boekaerts & Corno, 2005; Lin, 2001), a distinct shift has been identified from the direct teaching of metacognitive skills and strategies to more emphasis on changes in traditional classroom arrangements and the creation of social environments to support metacognition. Key elements of such social environments that can be identified more broadly from various elements of the research literature relate to the essentially social processes of learning, and the importance of the emotional and motivational context.

Two exemplary studies which illustrate these new emphases in theory and research are Perry's (1998) observations of second and third grade classrooms during literacy activities and the work of Meyer and Turner (2002) on the scaffolding discourse of teachers in sixth grade maths lessons.

Perry (1998) observed second and third grade classrooms doing literacy activities over a period of 6 months and, through observations and interviews with the young students, she explored the impact of types of tasks, forms of assessment and authority structures on the students' regulation during writing tasks, and perceptions of support and control as well as beliefs, value judgements and expectations in relation to reading activities. Based on her observations, she identified two different types of classrooms: High- and Low-SRL classrooms.

High-SRL classrooms were characterised by

- challenging and open-ended writing activities;
- opportunities for children to control the level of challenge;
- opportunities for them to engage in self-assessment;
- autonomy support through strategy instruction;
- encouragement of a mastery-oriented approach fostering positive feelings towards challenge;
- an emphasis on personal progress and
- a perception of mistakes as opportunities for learning.

In contrast, in Low-SRL classrooms, children were more likely to be engaged in restricted types of activities with limited choices. Evaluation procedures were mainly controlled by the adult and were similar for all students emphasising performance and triggering social comparison. The observation of the performance of these students revealed that the students in the High-SRL classrooms were more able than the students in the Low-SRL classrooms to engage in systematic and strategic approaches towards the tasks, operating in a flexible way and seeking assistance appropriately. The students' reports in semi-structured and retrospective interviews also indicated important differences. While the students in the High-SRL classrooms showed prevalence of a mastery-oriented approach which was evident even in students with low ability, the students in the Low-SRL classrooms were more prone to avoid engagement in challenging tasks and to show motivational vulnerabilities (Perry et al., 2002).

Similar findings emerged from Meyer and Turner's (2002) exploration of the scaffolding discourse of sixth grade teachers in maths lessons. In the context of this study, scaffolding was understood as

> *…an instructional process in which a teacher supports students cognitively, motivationally, and emotionally in learning while helping them to further develop autonomy*. (Meyer & Turner, 2002, p. 18)

Three different categories of scaffolding were explored: (a) scaffolding understanding; (b) scaffolding of autonomy through strategy instruction and gradual transfer of responsibility; and (c) scaffolding of the classroom environment emphasising positive feelings, collaboration and mastery orientation. In parallel, two categories of non-scaffolded instruction were identified: (a) teacher-controlled responses and (b) non-supportive responses. The findings from this research indicate that students who reported higher indicators of SRL participated in classrooms characterised by (a) positive and supportive classroom climates; (b) a strong focus on understanding; (c) encouragement of autonomy by shifting responsibility from the teacher to the students; and (d) shared responsibility for learning.

Interestingly, researchers working in the area of classroom dialogue have arrived at consistent conclusions about the types of teacher–students interactions that seem to be beneficial for students' learning and understanding (Alexander, 2004; Rojas-Drummond & Mercer, 2004). According to these researchers, teachers who encourage active participation on the part of the students, who provide opportunities for students to explain their reasoning, who support the acquisition of procedures and strategies, and who use questions that encourage the students to engage in reflective processes are likely to enhance their opportunities for learning. Despite the fact that this line of research has not directly addressed the impact of these practices in children's metacognition and self-regulation, the parallels are evident.

3 The present study

3.1 Aims and objectives

This article reports data from an observational study of young children's metacognitive and self-regulatory abilities in the context of mathematical activities in UK Foundation Stage classrooms. These classrooms were observed over a 2-year period within the Cambridgeshire Independent Learning in the Foundation Stage (C.Ind.Le) project, which explored the development of self-regulatory and metacognitive abilities in young children aged 3–5 years. The main research question driving this study related to the issue of whether metacognitive abilities are relatively late-developing (not emerging until middle or late childhood) or whether, given more sensitive methodologies and pedagogical approaches likely to support metacognitive development, they could be observed in much younger children. Previous articles have presented initial data and analysis supporting the view that metacognitive and self-regulatory abilities can be seen to be emerging in the 3–5 age group (Whitebread et al., 2005) and particularly in the context of mathematical activities (Coltman, 2006). At the same time, however, the contexts in which metacognitive and self-regulatory behaviours occurred were recorded and analysed. The present article focuses upon the aspects of pedagogy observed which appeared to support children's metacognitive development in this very young age group.

3.2 Participants

The teachers were selected to be included in the project based on evidence of their high level of skill as early years' educators and their willingness to be involved in a project which would require them to engage in innovative practices. They were also selected so that the whole cohort comprised a representative sample of types of pre-school provision and socio-economic catchment area in the Cambridgeshire region. The data reported here was collected from the classrooms of four practitioners, working in two nursery and two reception class settings, who had expressed an interest in focusing on the context of early mathematical activities. The numbers of children within these settings are listed in Table 1.

3.3 Procedures

Over the 2-year period of the study, regular training sessions were held to develop and support the teachers' understandings of relevant principles derived from previous research as outlined above. The teachers were encouraged to develop a range of pedagogical innovations within their mathematics teaching which were likely to support young children's metacognitive and self-regulatory abilities. Each classroom was visited on one occasion per term (i.e. 3 times each year) and the children were filmed while they were engaged in mathematical and other activities. The researcher and practitioner together agreed the focus of the filming, which lasted from between 30 min

Table 1 Number of children in the participant Foundation Stage settings

	Number of children a.m.	Number of children p.m.		Number of children
Nursery settings (3–4 year olds)			Reception classes (4–5 year olds)	
Nursery A	22	19	Reception A	25
Nursery B	26	26	Reception B	24
	Total 93 children			Total 49 children

to an hour depending on individual circumstances. The practitioner then viewed the video at leisure, selecting just two or three episodes or 'events' which they considered to be significant, illustrating important examples of children's self-regulated talk about their mathematical experiences.

These extracts of the video were then viewed together with the researcher. The discussion took the form of a 'Reflective Dialogue', a research tool developed by Moyles, Paterson & Kitson (2003). Practitioners articulated their reasons for selecting each sequence and the aspects of the video which had contributed to their pedagogical understandings or knowledge of individual children. The full conversation was recorded on audio tape. The footage of children engaging in mathematical activities on each video tape was, however, not restricted to those moments selected by the practitioners, and it was decided at an early stage to identify additional events for later analysis. Although these additional events were not the subject of discussion with practitioners, in every other respect they were subject to identical subsequent analysis.

3.4 Data analysis

The details of the development of the coding framework used to analyse the metacognitive and self-regulatory behaviours evidenced in the selected 'events' have been presented in a previous article (Whitebread et al., 2009). The final coding framework developed, as is typically the case with this kind of analysis, comprised a blend of a priori categories of behaviour deriving from previous research literature and new categories emerging from a 'grounded' analysis of the data. The a priori categories were derived from an analytical model of cognitive self-regulation, developed originally by a member of the C.Ind.Le research team within a related study (Pino Pasternak, 2006). This attempted to incorporate significant aspects of metacognition and self-regulation which, according to the current research evidence reviewed earlier in this article, appear to have an impact on the emergence of metacognitive and SRL within the 3–5 age range. This model involves three main areas:

- *Metacognitive knowledge* (Annevirta & Vaurus, 2001; Flavell, 1987; Pintrich, 2002; Schneider & Lockl, 2002): the individual's knowledge about personal, task and strategy variables affecting their cognitive performance. For example, a young child might indicate a personal knowledge of strengths and weaknesses in their mathematical capabilities.
- *Cognitive regulation* (Brown, 1987; Nelson & Narens, 1994; Pape & Wang, 2003; Son & Schwartz, 2002): the metacognitive processes taking place during ongoing activities, i.e., planning, monitoring, control and evaluation. For example, young children might show awareness of having made an error in calculation or counting, and use a different strategy, e.g., using fingers to check.
- *Emotional and motivational regulation* (Boekaerts, 1999; Corno, 2001; Zimmerman, 2000): the learner's ongoing monitoring and control of emotions and motivational states during learning tasks. For example, young children might use self-commentary to help themselves to resist distraction or to persevere in the face of difficulty.

This analysis of the children's metacognitive and self-regulatory behaviours enabled the identification of pedagogical features which appeared to particularly support metacognitive and self-regulatory performance by children in the 3–5 age group. For example, as we have reported earlier (Whitebread et al., 2007a), a quantitative analysis of the occurrence of self-regulatory behaviours showed that children often adopted the regulatory role within activities which they had initiated themselves, where an adult was not involved in the activity, and where the activity involved small group problem-solving, encouraging collaborative and peer-assisted learning.

Following this initial quantitative analysis, a qualitative analysis was undertaken of various subsets of the 582 metacognitive 'events' identified within the whole project, including 52 distinctively mathematical events which were either observed during planned mathematical activity or which gave evidence of children's mathematical thinking in child initiated activities (Coltman, 2006). The analysis aimed to investigate the more fundamental qualities of pedagogical interactions which appeared to support the children's self-regulatory development. The present article reports the findings from this analysis, and uses examples from the distinctively mathematical events which were included within it.

Coding this type of social behaviour is by its nature highly inferential, making it particularly important to establish clear definitions that support highly reliable interpretations. Issues of reliability in analysing the events were addressed in two ways. Early analyses of both utterances and pedagogical elements were carried out in partnership with a second researcher with each analysis discussed to a point of agreement. Later, randomly selected samples of codings of talk were independently validated by a third researcher. Results disclosed an agreement rating of 82%.

3.5 Results

Four clear characteristics emerged within this study of pedagogical interactions which seemed to provoke and support metacognitive and self-regulatory behaviours in 3–5-year-old children. As will be seen, these characteristics were very much in line with the previous analyses presented earlier in this article, within the work of such as Perry (1998; Perry et al., 2002) and Meyer & Turner (2002). The present study, therefore, demonstrates that the principles which have emerged within studies of older age groups also relate to this younger age group, and can be observed to be occurring in the settings and classrooms of able and innovative early years' teachers. These four principles relate to the establishment of emotional warmth and sensitivity between the teacher and child, to pedagogical practices which give children feelings of control over their activities and learning, which present children with cognitive challenges, and which require children to articulate their thinking. In the remainder of this article, selected pieces of interaction within mathematical contexts are presented and analysed which illustrate each of these four principles.

In undergoing this kind of behavioural analysis, it is, of course, important to distinguish between the child's cognitive activity in carrying out the task and behaviours which provide evidence of metacognitive knowledge and cognitive or emotional regulation. In each of the transcripts in the following sections, the right-hand column provides commentaries on the evidence which supported inferential analysis. As noted earlier, the coding framework guiding these analyses was shown to be robust with a high level of inter-rater agreement.

3.5.1 *Feelings of emotional warmth and sensitivity: making ten*

In this episode, a reception class teacher creates a relaxed environment designed to encourage informal conversation. Children and teacher share unstructured activity as they

Fig. 1 Making ten

Observed Activity	Analysis
Thomas : I'll tell you how many candles ten is. It is 3, 3, 3, 1. *No accompanying gestures visible as Thomas has his back to the camera.*	This utterance is not only a statement of intention, but is also an indicator of Thomas's own confidence that he is aware of what he knows. He demonstrates an explicit knowledge of his own capabilities in relation to his self selected task *Metacognitive knowledge of person variables: Self*
Teacher: *Not looking up from dough.* That's interesting.	
Sally: I know how ten goes too. Five and five.	Similarly Sally is offering evidence of an awarenes of her own knowledge. *Metacognitive knowledge of person variables: Self*
Thomas stands up and turns as he leans forward towards the teacher, securing her attention. Thomas: OK. Five and five. *He holds his right hand, closed in a fist, in front of himself. He raises the little finger and starts to count.*	The model of the finger counting is used to support cognitive activity, but in this instance the use of eye gaze and insistent tone of voice indicate that the speaker expects the listener to be guided by this model. The control is directed towards another. *Control and regulation: uses a model to support cognition: Other directed*
Thomas: It goes 1, 2, 3, 4, 5 *As each number is said, an additional*	In this observation specific hand gestures are used in conjunction with the speech, supporting the emphasis given to key words.

Fig. 1 continued

finger is raised until Thomas has his hand completely open. Thomas: That's five. *As he says this Thomas pushes his open hand forward towards the teacher.*	*Control/regulation: Using non-verbal gesture as a strategy to support own cognitive activity.*
Thomas now raises his left hand and repeats the same gestures and counting. Thomas: 1, 2, 3, 4, 5 and that's five.	Again this observation is suggestive of the use of gesture to support the cognitive activity of another, as a demonstrative explanation is offered *Control and regulation: uses a model to support cognition: Other directed*
After saying the number 2 there is a brief pause as Thomas looks towards his hand before resuming the count.	The pause in the recitation of the counting sequence indicates a process of checking. This inference is supported by the pattern of eye gaze. *Regulation: Monitoring: Checks performance*
Finally he holds both hands in front of himself and repeats the unfolding finger procedures matching this action to counting. This time he carries out the action with his right hand then left without interruption continuing the count to ten. Thomas: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.	Again a non-verbal series of gestures is used as a strategy to support cognitive activity, the inference being that it is intended to support the cognition of the listener. *Control and regulation: uses a model to support cognition: Other directed*
As he reaches ten his voice rises in pitch Teacher: That's wonderful!	The rise in pitch of the voice indicates excitement and pleasure in successfully achieving the end of the desired goal. This suggests a monitoring of emotional and motivational experiences and a recognition that achieving the goal is pleasurable. *Regulation: Emotional monitoring.*

manipulate dough together around a table. The context generated is one of parallel endeavour and shared enjoyment of the activity. The children are supported by the presence of the teacher who sustains a contributive but non-threatening demeanour. Her eye gaze is predominantly on the piece of dough she is manipulating, but at the same time she is engaging in shared conversations with the children, providing opportunities for them to explore ideas through talk. Thomas is sitting next to the teacher and is making her a 'birthday cake'. He has indicated that he is going to make ten candles for the cake. Sally is across the table making model snails. The details of the interaction, alongside an analysis of the metacognitive and self-regulatory behaviours evidenced by the children, are presented in Fig. 1.

Throughout this interaction, the teacher remains silent, but encourages Thomas's explanations through non-verbal indicators of appreciation. As he reaches the end of his demonstration, she exclaims 'That's wonderful'.

An interesting aspect of this interaction is that as he recites the numbers 3, 3, 3, 1, Thomas uses a personal coding system. The knowledge that these three numbers need to be added together to make ten is implicit, but not articulated. This suggests the use of verbal shorthand indicative of a strategic drawing together of concepts in the organisation of knowledge.

From a pedagogical point of view, this excerpt is a good example of the kind of emotional tone we commonly found established in the classrooms of our sample of able early years' teachers. The teacher here recognises the value of the mathematical exploration that Thomas is undertaking and shows sensitivity to his emotional and educational needs during this episode in resisting the temptation to interrupt him in any way, by offering any form of 'instruction'. Instead, what she does offer is clear emotional support and appreciation of his ideas. This sensitivity as to when to provide 'instruction' and when to let the children develop their own ideas in an emotionally

Fig. 2 Playing lotto

Observation	Analysis
Kate: *turning towards Alice,* How do you play it?	Kate indicates that she does not know how to play the game. Here eye gaze towards Alice suggests that she recognises that Alice has the necessary knowledge. This can thus be interpreted as seeking help. *Control and regulation: Seeking help*
Alice: It's easy peasy lemon squeezy.	Alice's use of a popular non-sense phrase indicates a judgement or rating of the level of difficulty of the cognitive tasks of the game. *Metacognitive knowledge of task variables : Demonstrating the explicit expression of own long term memory in relation to task*
Alice: You pick a card and if the number's right you put it on your board, and if it's wrong you put it back in the corner.	Alice then goes on to summarise and clarify the task requirements of the game, indicating how to proceed. This speech is indicative of a metacognitive process of planning; a verbalisation of procedures necessary for performing a task. *Regulation : Planning /reasoning/decision making*
Alice: Copy what I do. *Alice picks a card, looks at it and returns it to the pile without saying anything*	Alice's final instruction, that Kate should copy what she does, suggests a confidence in her ability to complete the task. *Metacognitive knowledge of person variables: Self*
Alice (*to Kate*) : Now it's your turn. Come on, I had a go. Pick a card. Pick one of them.	Again, Alice is clarifying task demands, but the choice of language combined with the direction of eye gaze suggests an element of encouragement. *Regulation: Emotional/motivational monitoring: Other directed*

Fig. 2 continued

Kate picks up a card and looks at it. It shows a clock face at six o'clock.	
Alice: Have you got that one? What number is it? It's six. You've got to have a six.	Here Alice appears to monitor Kate's performance. Her questions and instructions direct Kate's attention to key task elements. This is indicative of a monitoring process. *Regulation : Monitoring: Other directed* There is also an extent to which this observation could be interpreted as evidencing a process of control and regulation. Alice's sequence of utterances suggest that she is directing Kate to compare the number on the selected card to those on her lotto board. She is pointing out a strategy which will address the task effectively. *Control and regulation: Other directed*
Kate points to a square on her board which shows a clock face showing six o'clock.	
Alice: *pointing to the same square*: Is that a six? Yes. Six. *Kate puts the card in place.*	Here the interpretation was made that Alice is again directing Kate. Her use of the word 'yes' also indicates an element of encouragement. *Control and regulation: Other directed* *Regulation of motivation: Other directed*
Lynette: *turning to face Jade:* I've got three. You've only got two more. I've got three more.	Lynette has counted the number of squares remaining uncovered on her board. She compares this with the number of cards yet to be collected by Jade, her neighbouring player.
Jade: I'm going to win! I'm going to win!	Here Jade makes a connection between covering all the squares on her board and the completion of the game. The suggestion is that she is evaluating her progress towards a successful outcome. *Regulation: Evaluation: evaluating quality of performance*

supportive context might well be described as a form of emotional contingency.

3.5.2 Feelings of control: playing lotto

Alongside contingent emotional support, previous studies have also highlighted the importance of children's feelings of control and autonomy. Both Perry (1998; Perry et al., 2002) and Meyer & Turner (2002), for example, identified the support or scaffolding of autonomy through strategy instruction, and the contingent transfer of responsibility, as key elements within classrooms that support children's SRL. Throughout the present project, we commonly observed teachers establishing strategies and procedures for carrying out activities, which, as they were internalised by the children, provided a support structure which enabled them to become increasingly autonomous and able to take responsibility for their own activity.

In the sequence presented in Fig. 2, a reception class teacher provides an opportunity for children to work autonomously and collaboratively in completing a structured lotto game. Supporting the children's ability to take responsibility for the conduct of this game, and their learning within it, there are rules and strategies which have been previously established. In addition to the rules specific to the game, of matching and placing clock face images, the activity requires the children to follow aspects of procedural conventions such as waiting, turn taking and checking.

Of the group, only one player, Alice, has played the game before in a group that was teacher directed. Alice is now engaging in a peer tutoring activity, passing on her knowledge of the game as it is played independently by this group.

There can be little doubt that Alice articulated strategies, drawing on her own knowledge and thinking about how to convey it to others in a metacognitive process, but her approach was rather more didactic than explanatory. It is quite possible that she is demonstrating elements of strategic control as she employs language previously heard in another context, perhaps from the occasion when her teacher previously taught her how to play the game. Her utterance 'Is that a six?' can be viewed as an example of strategic coding, similar to that used by Thomas in the previous episode. The question actually meant 'Are the clock hands on that card in a position which indicates six o'clock?' This was effective use of verbal shorthand, understood within the group.

During the playing of the lotto game, several instances were observed by children prompting each other to take their turns through comments such as 'Come on', or 'It's your turn'. This group of children continued their game for over a quarter of an hour, seeing it through to conclusion. The teacher had had some reservations about the children's ability to complete this task without teacher support, but after the activity she commented on their motivation and perseverance as they played, persisting through difficulties and supporting each other, in ways which illustrate very clearly her pedagogical aim of establishing the children's autonomy and experience of control:

> *The children didn't go off task at all. They didn't need anybody. I went over once or twice just to ensure that everything was okay, but they didn't need any intervention whatsoever. The thing that impressed me was their adoption of the game conventions of taking turns and the understanding of the procedures involved in the game and being really quite formal about it. I have learnt that they can teach each other. They can teach each other and they can interact completely autonomously. You really wonder what are the limits with these children. They are so capable.*

3.5.3 Cognitive challenge: a house for Paws

A further aspect of a High-SRL classroom identified by Perry (1998; Perry et al., 2002) concerned allowing children the opportunity to control the level of challenge in tasks and fostering positive feelings towards challenge. A strong thread through the observations within the present study concerned the almost universal tendency of the children, given the opportunity, e.g., in free play, to set themselves targets, goals and challenges. In the episode presented in Fig. 3, a pair of children has been challenged by their reception class teacher to build a house for a large toy dog, but have been given considerable freedom within that general task to set their own targets and challenges. So, for example, the children were offered a choice of construction materials of different sizes, from which they selected a box of quite large traditional wooden building blocks. Their construction takes the form of a rectangular enclosure, which they decide should exactly fit the dimensions of the toy dog (which is called 'Paws').

As we see at the beginning of the excerpt, after building for a few minutes, they decide to check that the dimensions of their building, according to their set criteria, are appropriate. Later, a more sophisticated aspect of problem solving is seen as an element of the construction, a slide, was seen as potentially hazardous for Paws. In finding a resolution to this, the girls engage in collaborative problem solving, which includes strong elements of negotiation. In this interaction, which focuses on mathematical concepts of shape and measure, Sara takes the lead, but Ruby is able to

Fig. 3 Building a house for Paws

Observation	Analysis
Sara: Will Paws fit inside? (*Positions Paws, the toy dog, lying in the house*)	Here Sara is offering evidence of a monitoring process in the form of chacking. Her question indicates a desire to ascertain the degree to which performance is leading to the desired goal. Her non-verbal behaviour supports this interpretation. *Regulation: Monitoring*
Ruby: Yes he can go to bed in it. (Looking towards the toy dog lying in the house.)	Here the suggestion is one of evaluation. The direction of eye gaze indicates a consideration of the task progress and a rating of the quality of performance. *Regulation: Reflection/Evaluation*
Sara: (*puts in a sloping brick*) ……….(*inaudible*) a slide.	
Ruby: What if he slides down there and bumps his head?	This utterance is suggestive of processes of monitoring. The inference in that Ruby is reviewing task progress and detecting a possible error. *Regulation: Monitoring*
	There is also evidence of reasoning as Ruby makes the link between the slope of the block and the action of sliding. *Regulation: Reasoning*
Sara: Well we don't put that there then …	The inference here is that Sara is suggesting a solution to the problem. She has decided on a way of proceeding with the task. *Regulation: Decision making*

Fig. 3 continued

Ruby: There's going to be two (*putting in second sloping block adjacent to the first which has the effect of making the ramp wider*)	Ruby similarly offers evidence of a metacognitive process, but in this case her verbal statement is accompanied by the non verbal action of positioning an additional block .This change of strategies results from her previous cognitive monitoring of task progress. *Regulation: Control*
Sara: (*moving both sloping bricks close together,*) OK, that can make the ramp a bit bigger	In response to Ruby's monitoring and strategic control, this utterance, supported by non-verbal activity, suggests that Sara has reflected upon the procedural adaptation and in an evaluative process has rated it positively . *Regulation: Evaluation*

present arguments which cause Sara to adjust the strategies adopted.

The richness of this context in which children had complete control over a problem which was both real and purposeful demonstrated the power of 'utility value' as described by Pintrich (1999). The children were genuinely interested in their task and had an investment in the achievement of their self-determined goals. The wealth and diversity of the forms in which the children demonstrated this type of metacognition were recognised by the teacher who facilitated it. Her comments recognise the elements of strategic control revealed by the children's conversations as they made their planned and developed strategies for achieving their goals:

> *They (Sara and Ruby) worked really nicely together. They how it would be big and how they would need all the blocks and it would take them all day and they would have to be quick or it would take till midnight, and things like that. It just showed a good understanding of time and they recognised that it would take longer to build a bigger house than a smaller house. They were talking about the different sizes and what the different shapes were and what they could use them for, like ramps and chimneys. And they thought they needed a door so they were leaving a space for the door. And they were really thinking it out carefully.*

3.5.4 Articulating thinking: teaching Rosie to count

Finally, our fourth pedagogic principle recognises that, even with such young children, opportunities for talking about their thinking and learning were of clear significance. This is very much in line with the work which has established the benefits for learning of 'dialogic teaching' (Alexander, 2004) and 'exploratory talk' (Rojas-Drummond & Mercer, 2004) with older age groups.

The episode presented here in Fig. 4 exemplifies the placing of mathematical challenges within a context within which articulating their thinking and learning was perceived by children to be relevant and purposeful. An almost child-sized signing puppet, Rosie, was introduced as a new pupil to the class who needed the help of children in carrying out mathematical tasks. In helping Rosie to perform counting activities along a number line, the children, in role as directors, of necessity drew upon and articulated their own skills and knowledge, providing evidence of metacognitive processes through mathematical language supported by non-verbal gestures.

In this interaction, Rosie, operated by the teacher but directed by the children, has ordered some numbered carpet tiles into a line from 1 to 10. The children are seated on a rug to one side of the number line. Throughout this episode, the teacher interacts verbally with the children in a different 'voice' as she takes on the role of Rosie the puppet.

Fig. 4 Teaching Rosie to count

'Rosie': Is that right? How do you know that that's right?	
Liam: 'Cos it always starts from zero, then its one, then two, then three, then four, then five then six, then seven, then eight, nine ten. *As he speaks Liam points towards the numbered tiles, moving his finger from left to right in a rhythm that matches his counting.*	As Liam articulates his knowledge of number order, his eye gaze is not directed towards the puppet. This suggests that his strategic action in using a pointing action to support his counting is self directed rather than other. *Regulation: Control: Using non-verbal gesture as a strategy to support own cognitive activity.*
'Rosie':: Does it always go like that?	
Liam: Well you could have put the zero at that side (*pointing to the end of the line currently occupied by the number 10)* and go 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. *Liam points to each tile in turn matching hand movements to counting words. Occasionally he looks towards the puppet as he does this.*	In this observation Liam articulates a memory knowledge of possible strategies that can be employed in order to achieve the goal of number line construction. *Metacognitive knowledge of strategy variables* The non-verbal gesture of finger pointing in this instance is well
	defined and emphatic, and there is intermittent eye gaze towards the puppet. The inference is that this is intended to support the cognition of the puppet 'pupil'. *Control and regulation: uses a model to support cognition: Other directed*
'Rosie':: So we could make the line start at the other end?	

Fig. 4 continued

Liam: Yes, you can if you want.	Although this single utterance invites possible interpretations linked to motivational regulation directed towards the puppet, or of an implicit evaluation of alternative strategies, the strongest indication here is that Liam is again articulating his knowledge of strategic options. *Metacognitive knowledge of strategy variables*

As we can see, in the role of 'teaching Rosie', Liam articulates some rather sophisticated understandings about numbers and counting. The device of Rosie proved effective in eliciting a range of insights into children's mathematical understandings. On another occasion, for example, another child, asked by his teacher to think of an easy addition for Rosie to carry out, was quick to respond 'one and two makes three'. In this instance of the metacognitive rating of a task, he suggested an understanding typical of young children that the lower the numbers involved in an operation, the greater the ease will be in solving it. The potency of Rosie as an effective classroom device in engaging children and inspiring confidence in instigating and talking about mathematical ventures was once again very effectively described by the teacher:

> *We had introduced the fact that Rosie the puppet had started to go to school now and was starting to learn her numbers. The children had to help her to learn her numbers. So they were helping her do counting: jumping along the number line and counting. And then they suggested sums. Yes. The group had suggested sums, and we started working out how we could do the sums on the number line.*

4 Discussion

As we noted at the outset of this article, there is growing evidence that early conclusions about the late onset of metacognitive abilities drawn from self-report and laboratory-based studies may have been misguided. It has been commonly observed in the literature, for example, that children in the 3–5 age range are often unable to articulate their internal mental processing, even when they can perform tasks successfully. The evidence from the present study, however, as we have seen in the last excerpt, appeared to support the view that, at least in some of the previous literature, this could be a contextual and methodological problem. Shamir, Mevarech and Gida (2009) have demonstrated that 4–5-year-old children show significant differences between their declarative (self-report) and procedural metacognitive abilities. When the children in the present study were given reasons for articulating their thinking which made sense to them, they appeared to be more capable in this regard than perhaps previously indicated. Observational studies of young children's metacognitive and self-regulatory abilities, as we discussed earlier in the article, have now consistently shown that, when tasks are placed in contexts which make sense to young children, they can demonstrate clear signs of emergent metacognitive and self-regulatory skills. Excitingly for educators, it also appears that individual children's progress in developing these skills can be significantly influenced by particular pedagogical practices. We have presented evidence from the present study that these practices, with children in the 3–5 age range, include providing contingent emotional support within emotionally warm and sensitive relationships, supporting children to exercise their autonomy and achieve feelings of control, set their own challenges and develop positive dispositions towards cognitive challenges, and developing contexts which provoke and support children's articulation of their own knowledge and thinking. Of these, perhaps the most challenging for practitioners working with this young age group to develop is the last. Future research exploring practical pedagogical approaches which encourage and support young children to articulate their thinking, and the cognitive processes by which such talk supports metacognitive development, would be of enormous value.

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