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Do mathematics learning facilitators implement metacognitive strategies?

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It is widely accepted that mathematical skills are critically important in our technologically sophisticated world. Educators' metacognition directs, plans, monitors, evaluates and reflects their instructional behaviour and this can promote learners' learning with understanding. The purpose of this study was to investigate the extent to which mathematics educators implemented and taught metacognitive strategies. Results of the quantitative part of the study were triangulated with the results of the qualitative part. Results suggested that whereas mathematics educators may well have possessed metacognitive skills and utilised them intuitively, these skills were not implemented to a satisfactory extent in the classes we observed.

Introduction

Since mathematics is generally accepted as a gateway subject ("enabling discipline") (Pandor, 2006a:2) to tertiary study, it can be described as a critical mass in secondary education, and adequate learning facilitation in this subject is of pivotal importance in any country. Even though South Africa (SA) spent R30 million on bursaries to take an Advanced Certificate in Education to over 4 000 mathematics, science and technology teachers between 2002 and 2005 at the end of 2006, the already alarmingly low pass rate in mathematics dropped even further, causing Naledi Pandor (Minister of Education) to state categorically: "We will have to pay much closer attention to performance in these subjects ... We need to determine focused strategies to improve learning outcomes" (Pandor, 2006b:6).

Facilitating mathematics learning is not only a South African problem, it is a cause of concern to countries throughout the world. The question may well be asked why formal schooling cannot guarantee that learners acquire an adequate level of mathematical skill. Although it is well known that mathematics plays a major role in life and in the progress of countries in the twenty-first century (Ball, Lubienski & Mewborn, 2001), Grades 9 and 12 learners still discontinue their formal schooling without having acquired an interest or skill in mathematics.

Analysis of the results of the Third International Mathematics and Science Study – Repeat (TIMSS-R) (Howie, 1999) shows that 27% of the South African learning facilitators (indirectly) involved in the study, had never had formal training as mathematics learning facilitators.

Our purpose was to describe steps taken to investigate the extent and nature of learning facilitators' metacognitive (thinking) strategies in mathematics classrooms in the senior phase. We tried to answer the question whether learning facilitators actually applied metacognitive thinking strategies in mathematics classrooms. We believed that metacognitive strategies could be facilitated successfully for learners in mathematics classrooms in South Africa (SA). We hoped to enable greater understanding of the nature of metacognition and metacognitive strategies and skills, specifically as these concepts relate to teaching and learning of mathematics. In addition to explicating ways to help teachers implement metacognitive strategies and skills in their classrooms, we delineate the need to advance our theory base in the teaching and learning of mathematics to one more appropriate. This question also alludes to investigating whether or not mathematics teachers actually possess metacognitive skills themselves. Following this introduction, we focus on (a) the need for such research, (b) an analysis of what exactly the concept metacognition (and related concepts) entails, (c) miscellaneous aspects of metacognition and metacognitive skills and strategies, (d) our research design, (e) some statistical data in so far as these were relevant for a report of this nature, and (g) in conclusion discussion of the results and provision of motivated recommendations and suggestions for further research.

Motivation for the research

The Third International Mathematics and Science Study Repeat Survey (TIMMS-R) of worldwide trends in scholastic performance in mathematics and physical science (gateway subjects for tertiary education) confirmed once again that South African mathematics learners' performance was significantly poorer than that of the vast majority of other participating countries in the tests that measured basic mathematical skills (Howie, 2001:18). South African learners struggled to deal with word problems and experienced great problems with fractions and sums in which geometry had to be used to calculate area. In general, learners experienced many problems in communicating their answers in the language of the test (English) and they gave indications that they did not have the basic mathematical knowledge required of Grade 8 learners. Moreover recent research has revealed that the vast majority of Grade 6 learners in the Western Cape in South Africa (normally one of the top achieving provinces in South Africa) have not even mastered the literacy and numeracy levels expected of Grade 4 learners (Kassiem, 2004).

In our experience (both of us are vastly experienced in the field of mathematics teaching), learning facilitators rarely, if ever, demonstrated to their learners exactly what 'learning how to learn' means: the meaning of 'thinking about one's own thinking', and how to become a problem solver. Instead, the message sent out consistently has been the following: The best problem solver is the one who finds the 'right' answer according to the 'right' method first. It became clear to us that the vast majority of learners followed a 'recipe', without appropriate insight into the nature of problem solving. In fact many learners did not have the slightest idea what exactly it was that they were doing. To this day, 'learning how to learn' still does not form part of the South African school curriculum.

Defining some critical terms

Metacognition

Metacognition is defined as individuals' ability to adapt cognitive activities and understand better (Brown & Palinscar, 1982). Effective thinking, learning and learning facilitation require regular control, statement of purpose, re-assessment of what has been done or that which one is busy with, as well as assessment of outcomes (Gravelek & Raphael, 1985).

Learning facilitators/learners who are metacognitively aware of themselves as learning facilitators/learners possess strategies to establish what it is that they need to do when they are confronted with non-routine assignments. The use of metacognitive strategies activates learners' thought processes, thereby facilitating deeper learning and improved achievements (Anderson, 2002).

Some learning theoreticians regard the very essence of "metacognition" as metacognitive knowledge (static source of knowledge) and metacognitive self-regulation (metacognition in action) (Ertmer & Newby, 1996). Metacognitive knowledge is frequently refined into person, task, and strategy variables on the one hand and, on the other hand, as declarative, procedural, and conditional knowledge (Brown, 1980). Whereas metacognitive self-regulation is regarded as the implementation of planning, monitoring and evaluating, metacognitive knowledge and these activities throughout are actively linked by reflection. Reflective thinking transforms the knowledge acquired during problem-solving, after completion of the assignment/problem, into knowledge that is available for the next assignment/problem (Ertmer & Newby, 1996).

Learning facilitator

For the purposes of this article, the terms 'learning facilitator' and 'teacher', as well as 'teaching' and 'learning facilitating', are used interchangeably.

Metacognitive and cognitive strategies

Since each of these is involved in effective learning facilitation and learning, but has a distinctive and important function, Flavell (1979) draws the following distinction between 'cognitive' and 'metacognitive' strategies: Whereas cognitive strategies are evoked to facilitate cognitive progress (execute the task), metacognitive strategies are implemented to monitor, plan, control, and evaluate the outcomes and reflect throughout (Flavell, 1979).

Brief literature overview

International literature on mathematics learning facilitation and metacognition

During the past two decades researchers internationally have moved away from mere investigation of learning facilitators' conduct (behaviouristic view of the learning facilitator) to a study of learning facilitators 'cognitions' (cognitive view on the learning facilitator) (Brown & Baird, 1993). The National Council of Teachers of Mathematics (NCTM, 1989), for instance, indicated that problem-solving in mathematics should be an important focus in mathematics classrooms. Problem-solving is, in the first instance, a way of thinking, of analysing situations, of using skills to reason out what cannot be learnt by memorising specific facts, but by absorbing oneself in the problem-solving process and applying existing experiences and existing knowledge to the problem that has to be solved (Schoenfeld, 1985a; 1992). Learning facilitation in mathematics is regarded as 'problem-solving' in which metacognition plays a well-defined role since problem-solvers, by default, become involved in cognitive and metacognitive behaviour when they attempt to solve problems. Problems are solved in three stages, namely, planning to solve the problem; the actual solving of the problem; control, evaluation of, and reflection on, the solution (Artzt & Armour-Thomas, 1992).

Locally, this move towards perspectivity in mathematics education has followed international trends. However, very little research has been conducted in South Africa on metacognition in the mathematics classroom.

Policy documents

The National Curriculum Statement

The South African National Curriculum Statement Grade R–9 (Schools) (Department of Education, 2002) for the learning area Mathematics stresses the importance of problem-solving, reasoning, communication, and critical thinking. The National Education Policy Act (DoE, 1996) requires a learning facilitator to play seven different roles, *viz*. Learning mediator; Interpreter and designer of learning programmes and materials; Leader, administrator and manager; Scholar, researcher and lifelong learner; Community, citizenship and pastoral role; Assessor; and Learning area specialist (DoE, 2003). Some of these roles directly imply metacognition. As facilitator of learning, assessor and subject specialist, the learning facilitator should have a thorough knowledge of his/her subject, teaching principles, strategies, methods, skills, and education media as applicable to South African conditions. Facilitators should also be able to monitor and fairly evaluate learners' progress, their knowledge, insight, and views on teaching strategies and learning so that these factors can be utilised during the design and implementation of learning curricula.

The aim and unique features of the teaching and learning of mathematics established by the National Curriculum Statement Grade R-9, as well as for Grade 10–12 schools, which refer to metacognitive skills (directly or indirectly) include the following (DoE, 2002): The teaching and learning of mathematics aims to develop:

- A critical awareness of how mathematical relationships in a social, environment-cultural setting can be used in an economic context.
- The necessary self-confidence and competence to deal with any mathematical situation without fear of being impeded by mathematics.

Furthermore the teaching and learning of mathematics should enable learners to:

- Develop in-depth concepts in order to understand mathematics;
- acquire specific knowledge and skills related to study in mathematics (DoE, 2002:4-5).

The implication thereof is the development of metacognitive strategies and skills. Learning facilitators have at their disposal a number of strategies with which they can improve metacognitive strategies. Ideally, it is essential for learning facilitators not only to facilitate metacognitive strategies, but also to create opportunities for learners to apply and practise these skills. Learning facilitators ought to model their way of thinking and discuss this matter with learners, in order to enable learners to recognize their thinking skills. It should be expected of learners to gradually take responsibility for planning and regulating their own learning.

Even those learners who apply metacognitive skills and strategies are unsuccessful from time to time. In essence, insufficient metacognitive skills implies an inability to learn successfully (Baker, 1982; Wong, 1991). Wong (1991) recommends that learners showing evidence of an inability to learn satisfactorily be taught to implement metacognitive strategies and self-regulating behaviour — one should probably add: and to reflect on their own behaviour. Learners' metacognitive knowledge base may be insufficient (jeopardising the implementation of metacognition), in the same way that learners may have an insufficient knowledge base (Garner, 1987).

The aim of metacognition

Cardelle-Elawer (1995) distinguishes between the following three reasons why metacognitive strategies are essential: they stimulate and develop an individual's thoughts to attain insight into their own thought processes; when individuals judge their own thinking, this guides and steers their activities during problem solving; the classroom environment becomes a place where interaction and investigative attitudes are encouraged by means of discussions between learning facilitator and learners. These discussions do not only include what needs to be learnt, but also how and why learning needs to occur.

This process-view of teaching and learning, that metacognitive knowledge activates metacognitive experiences, which, in turn, activate the use of certain metacognitive strategies (Garner, 1987), contrasts strongly with the traditional approach to the facilitation of mathematics teaching and learning where the learning facilitator (teacher) focuses only on content.

Worldwide a change in emphasis is occurring, with education institutions gradually changing from places that "provide tuition" to places that "facilitate learning" (Barr & Tagg, 1995). This paradigm shift is from "instructivism" to "constructivism".

Some aspects of constructivist learning facilitation in mathematics

The constructivist approach to learning facilitation tends to focus on more learner-directed environments. This approach is associated with activities that facilitate knowledge construction and facilitate learning (Baylor, 2002). Driscoll (2000) distinguishes between the following five features of constructivist learning facilitation: (a) learning occurs in complex and realistic environments; (b) provision is made for social negotiations; (c) various perspectives support this facilitation and representations are accepted in various ways; (d) learners are encouraged to take responsibility for their learning; (e) these learners' attention is focused on their being aware of the process of knowledge construction (metacognition). These factors have particular implications for the purpose of learning facilitation in mathematics.

The aim of learning facilitation in mathematics

Grossnickle, Reckzeh, Perry and Ganoe (1983) indicate that since the 1980s learning facilitation in mathematics has been distinguished by the following: learning facilitators and other role players (e.g. authors of mathematics textbooks) are not only supposed to know and understand the content of the subject — they should also understand the particular development levels as the way in which learners understand and learn mathematics. Furthermore the facilitation of problem-solving strategies should be given preference and the learning facilitator should have a functional knowledge of the language and structure of mathematics — which includes, among other things, the following: the ability to estimate, to decide whether the answers to problems are acceptable or not, an intelligent command of calculating skills and abilities that indicate insight into the reasons why certain mathematical functions are carried out in particular mechanical ways.

Metacognition and the learning facilitator

For the purposes of this study suffice it to mention the description of Artzt and Armour-Thomas (2001), namely, that the learning facilitator is a problem-solver who ought to solve problems (learning facilitation) metacognitively but also to direct and guide learners to acquire metacognitive strategies and skills (Hartman, 2001b). This implies that a learning facilitator does not only challenge learners intellectually, but also supports them in their efforts to acquire and effectively learn strategies and skills — in other words, addresses critical mass issues in the mathematics class.

Jackson (1968) regards learning facilitation firstly as a solution to a problem, and for this very reason he distinguishes between pre-active, interactive and post-active phases of learning facilitation.

Components of the learning facilitators' metacognitive strategies and skills

Artzt and Armour-Thomas (2001) categorize learning facilitators' knowledge, convictions, aims and thinking processes as metacognitive components that are utilized during learning facilitation, and that should be implemented before, during, and after the learning facilitation opportunities.

Schulman (1986) defines the learning facilitator's knowledge (with respect to knowledge content and metacognitive knowledge of learners, learning, learning facilitation and learning facilitation strategies) as an integrated, multidimensional system of internalized information (knowledge and understanding) about learners, learning area content and learning facilitation that greatly influences mathematics learning and its learning facilitation (Fennema & Franke, 1992).

Convictions indicate assumptions concerning the nature of learning, learning content and learning facilitation that influence the perceptions, judgement and conduct of learning facilitators. These facets of mathematics learning act as filters through which new mathematics content can be interpreted and through which meanings can be linked with experiences. Embedded in the above are assumptions concerning learning-area content, learners and learning (Artzt & Armour-Thomas, 2001).

Outcomes, emphasizing conceptual as well as procedural understanding, are defined as intellectual, social and emotional outcomes that learners should attain as a result of learning facilitation and experiences (Cobb, Yackel & Wood, 1991).

Artzt and Armour-Thomas define learning facilitators' thought processes lastly as mental activities that are implemented to take appropriate decisions and to make judgements before (planning) during (monitoring and regulating) and after (assessment/evaluation and reflection) learning opportunities. These aspects of learning facilitators' thinking are not conceptually distinguishable, but are components of a complicated configuration of interdependent development processes and implementation schemes (Clark & Peterson, 1986).

The research problem will now be explicated against the background sketched above.

Research problem and aims of the study

The research problem to be investigated was the following: Do mathematics learning facilitators in the senior phase implement and teach metacognitive strategies? We analysed the nature of these strategies carefully in an attempt to help us in our own efforts to provide education departments with some 'traffic lights' in mathematics classes in the 21st century.

Research design

We implemented a quan-qual design, implying that a quantitative approach supplemented by a more qualitative approach was used. Questionnaires were filled in by mathematics facilitators at a particular time (quan). These results were later followed up by focusing on one[2] Grade 9 mathematics facilitator's metacognition and metacognitive strategies during learning facilitation (qual). No intervention was carried out.

Sample

Availability sample of mathematics facilitators for quantitative part of the study

Twelve mathematics facilitators, at the six schools involved in the greater study in Potchefstroom and Ikageng, agreed to participate in the study. Another 28 mathematics learning facilitators completed the self-assessment questionnaire at the AMESA conference (Association for Mathematics Education of South Africa, 27-30 June 2005, Kimberley) (Tables 1, 2, 3).

Table 1 Frequencies of ages and gender of the learning facilitators

Variable	Number of learning facilitators
20–30 years	6
30–40 years	17
40 years/older	17
Total	n = 40
Male	19
Female	21

Table 2 Frequencies of mathematics learning facilitators' years of experience

Years of experience per interval	Number of learning facilitators
0–5 years	7
6–10 years	11
11 years or more	22

Table 3 Frequencies of mathematics learning facilitators per school phase

School phase		Number of learning facilitators
Foundation	Grade R–3	2
Intermediate	Grade 4–6	6
Senior	Grade 7–9	24
Further education and training	Grade 10–12	8

Qualitative participant

One mathematics learning facilitator, at a dual-medium school in which all races were represented, was asked to participate in the qualitative study. This was done in order to obtain a representative (language, race and gender) group of learners during the learning facilitating opportunities in the Grades 8 and 9 classes.

Limitations of the study

The study was conducted on a relatively small group (availability sample) of mathematics learning facilitators over a limited time and in a limited context and consequently the generalisation value of the study is limited.

Methodology

Data collection/processing instruments/procedures: Quantitative part

Learning facilitators assessed their own implementation of integrated metacognitive strategies in the learning facilitation of mathematics by filling in the self-assessment questionnaire (Commonwealth of Pennsylvania, 2002:1). Examples of questions that were used were: I do the following in order to help learners in my class to develop into independent learners: (A1) I teach metacognitive strategies; (A2) I implement co-operative learning (group work). Learning facilitators assessed their own conduct while facilitating learning and marked the applicable response on a five-point scale. The responses varied from *I do this throughout (always)* — (5) to *I never do this* — (1).

Descriptive statistics were used (averages, means, standard deviations, and Cronbach α value) to analyse the data. All statistical calculations were done with the aid of SAS (SAS Institute Inc., 2005).

Data collection/processing instruments/procedures: Qualitative part

Since the research participant planned her own learning opportunities in mathematics, and designed and presented them herself, various types of data were obtained: video recordings of learning facilitating opportunities and of interviews before and after learning opportunities, as well as verbatim transcriptions of all video recordings.

Structured interviews were conducted with the learning facilitator before and after each of the two learning opportunities. Video recordings of the actual learning opportunity were analysed and questions were asked to enhance insight into the dynamics underlying the learning opportunity. The analysis procedure designed by Artzt & Armour-Thomas (2001) was implemented and the following three questions needed to be answered:

1. How does the learning facilitator prepare to solve the problem? (Planning: interviews preceding the learning opportunities);
2. How does the learning facilitator solve the learning facilitation problem in the classroom? (Monitoring and regulation: content of actual learning opportunity); and
3. How does the learning facilitator ensure that the learning facilitation problem has been solved? (Reflection and evaluation; interview after the learning opportunities have been concluded).

Results

Quantitative part

Quality assurance: Reliability

Cronbach α values of 0.92 were regarded as acceptable for the purposes of this study.

Results of the mathematics learning facilitators' questionnaire

The values in Table 4 indicate that:

- Fourteen of the 18 items resulted in a 3(Me)-response ('per occasion/ sometimes') and only four of the items resulted in a 4(Me)-response ('regularly') for the mathematics facilitators. Standard deviations (Table 4) of the 3(Me)-response for the medians implied that responses varied from 'I do this seldom/almost never', 'I do this on occasion/sometimes' to 'I do this regularly'. These results implied that mathematics teachers did implement metacognitive strategies, but inconsistently.

- Mathematics facilitators stated that the strategies when facilitating learning in mathematics included the following (Table 4, means, medians and standard deviations for A1, A5, A9, A13):
  - metacognitive strategic teaching (A1)
  - thinking aloud strategy teaching (A5)
  - private talk and internalising modelling (A9)
  - teaching problem-solving strategies (A13)

Note that mean scores of 2.9 or 3 on the five-point-scale did not imply that teachers, for example, did not implement co-operative learning (A2) or that this facet was necessarily poorly presented. It only implied that these strategies were not implemented on a daily basis or coherently.

Table 4 Arithmetic means ($\bar{x}$), medians (Me) and standard deviations (SD) for the self-assessment questionnaire for mathematics learning facilitators (N=40)

	Variable	$\bar{x}$	Me	SD
A1	(thoughts about their own thinking)	3.7	4	0.9
A2	(co-operative learning)	2.9	3	1.0
A3	(peer support/buddy system)	2.9	3	1.1
A4	(learning and repeated learning)	2.6	3	1.0
A5	(modelling how to learn by thinking aloud)	3.9	4	0.9
A6	(learning strategies section, discussions, various learning styles)	2.9	3	1.0
A7	(self-question strategies)	3.0	3	1.0
A8	(strategies to learn mathematics independently)	3.1	3	1.0
A9	(private talk and internalising strategies)	3.7	4	1.0
A10	(extension strategies)	3.1	3	1.0
A11	(monitoring strategies)	3.3	3	0.9
A12	(regard higher order thinking as a challenge)	3.3	3	0.9
A13	(problem-solving strategies)	3.4	4	0.9
A14	(various problems: different aims)	3.1	3	1.0
A15	(various problems: types of problem)	3.3	3	0.9
A16	(teaching and opportunities: reading, writing, listening, talking ...)	3.2	3	0.9
A17	(application of strategies that were taught)	3.1	3	0.9
A18	(self-assessment: learning strategies and mathematics achievement)	3.2	3	0.9

Results of the qualitative part

Pre-phase: Interviews concerning the planning of learning opportunities

The learning facilitator explained that the classes were English Grade 8 and Grade 9 classes, respectively, in which, in each of these classes, at least a third of the learners did not have English as a mother tongue.

According to the learning facilitator, the Grade 8 learning facilitating opportunity in geometry laid the foundation for "*Lines, angles so that we can lay a firm foundation for the concept and basis of geometry*". However, the main aim of the Grade 9 learning facilitating opportunity was to explain how two triangles can be proved congruent.

The learning facilitator explained exactly how she would achieve these aims:

Grade 8: "*I try to bring these things from home ... Where do you see something at home that is just a line? What does this mean to me — not just in writing?*"

Grade 9: The learning facilitator intended to concentrate on the structure of the proof of the congruent triangles, as well as to obtain the necessary information for the proof, from the sketch(es). She explained: "*I do everything with them on the blackboard ... That which they know, we must now apply.*"

Interactive phase: Summaries of actual learning facilitating opportunities

The learning facilitation took place briefly as follows:

Grade 8: The learning facilitator began with the basic concepts and guided the learners throughout by means of a questioning strategy: "*What is a line? What is an angle?*" Questions were put to the whole class. Learners answered simultaneously.

Grade 9: The learning facilitator demonstrated to learners how sketches in geometry should be analysed and understood. "*Some or other way we must make it easier for ourselves to prove that two triangles are congruent ... but we have to find a way you guys will also understand.*" While questions were posed and answered by the group, the proof was written on the blackboard.

Post-phase: The learning facilitator's comments on the video's of the learning opportunities

The learning facilitator made the following comments during the post-interviews:

Grade 8: "*The learners reacted in the way I expected they would. They argue and question what you say. I think this is a good thing.*" She also stated that the learners "*think they know and as they begin to talk, they realise that they do not understand*".

Grade 9: The learning facilitator explained: "We have received numerous complaints, from other staff also, that children cannot hear and see and recall ..." She added: "*I deliberately left this one on the blackboard, and did the other one next to it so that they can see: OK, if I am perhaps unsure, how did I do the previous one?*" The learning facilitator stated: "*I struggle to understand what the children do not understand ... I don't know. I have told them so many times, tell me exactly what you see ... or do not see. See, I struggle to understand why they do not grasp it.*"

Table 5 Summary of the learning facilitator's metacognitive thinking patterns

Metacognition	Component of metacognition	The metacognitive thinking patterns as observed during learning facilitations of the learning area Mathematics
As a whole	Knowledge: learners (person)	Facilitator revealed knowledge of learners in relation to their understanding
	Knowledge: learning area content (assignment)	Facilitator revealed conceptual and procedural understanding of the content; saw the content in relation to total area of mathematics and the necessity thereof for future use
	Knowledge: education (strategies)	Facilitator focused on the content Facilitator anticipated certain problems because non-mother tongue learners were involved and planned accordingly
	Convictions: role of learners	Facilitator regarded learners as active participants who had to think, provide answers, give attention and keep up
	Convictions: role of learning facilitator	Facilitator regarded herself as the facilitator of the learning of learners by asking questions, and as a role model of how to "do" problems
	Aims	Facilitator wanted to transfer content and help learners to acquire thorough procedural skills
Pre-phase	Planning of learning opportunities	Facilitator did no written planning because she felt she knew what to do and how to go about it; showed a thorough knowledge of the content of the learning area of mathematics; focused on the procedures that had to be learnt; organised the assignment according to existing knowledge and understanding of learners; made use of unambiguous examples and explanations
Interactive phase	Regulation	Hoping to involve all learners actively in the learning opportunity, the facilitator expected all learners to answer all the questions **simultaneously** (questions required very short, direct answers) Facilitator expected no explanations for the answers of learners and did not assess answers Facilitator dealt with understanding or misconceptions at the end of each learning opportunity Learning facilitation was done according to the original unwritten planning of the learning facilitator Learner facilitator facilitated no verbal interaction between learners Learner facilitator helped learners at their desks during the last few minutes

Table 5 continued

Metacognition	Component of metacognition	The metacognitive thinking patterns as observed during learning facilitations of the learning area Mathematics
Post-phase	Assessment/ Evaluation	Facilitator assessed the achievement of the outcomes of the learning opportunities in keeping with the content that had been handled
	Reflection	Facilitator expressed her satisfaction at the way the learning opportunities had proceeded, stating: "No changes are necessary"

Summary of the learning facilitator's thinking patterns

In Table 5 the learning facilitator's metacognitive thinking patterns (as observed by the researcher) are summarised according to the metacognitive components categorised by Artzt and Armour-Thomas (1992) and summarised in this article.

Discussion

It was evident from our findings that learning facilitators supported question-posing strategies and think-aloud models (Table 4: A5, A7), but did not necessarily create adequate opportunities for learners to implement and practise these procedures (Table 5). To some extent these findings linked up with Hartman's finding (2001a) that learning facilitators think aloud and ask questions so that learners can see and hear how to plan, monitor, evaluate and know how to approach assignments. She regards this as a technique that the learning facilitator can use to externalise thinking processes when the learning facilitator and learner are involved in an assignment requiring thinking. It was noticeable that learners in the classes observed were not really given the opportunity to pose self-questions, to practise, or to think aloud. This facet acquires special importance, especially when viewed against the background of Hartman (2001a) who believes that to put questions to oneself is an effective way of promoting self-regulated learning. She is furthermore of the opinion that this too has to be facilitated so that learners know when, why, and how to regulate their own thinking.

The findings furthermore indicated that, even though learning facilitators implement problem-solving (i.e. breaking the problem up into smaller steps, investigating the facts inherent to the problem, posing questions and answering them, controlling themselves and, through their thinking, arriving at a solution to the problem) (Table 4: A13, A14, A15 and Table 5), the strategies and steps that are followed (prediction, planning, monitoring, evaluation and reflection) are not directly facilitated or explicitly mentioned in the classes that were observed (Table 5). Schoenfeld (1985) found a relationship between inadequate facilitation of problem-solving strategies and negative achievement in the solving of mathematics problems. This occurs precisely because learners frequently possess the necessary factual knowledge in mathematics, but are unable to apply this properly because they do not know how to monitor or evaluate their conduct, or even how to speculate on where and when this knowledge should be implemented. Schoenfeld (1983) indicates that skilful problem-solvers' problem-solving is facilitated by metacognition.

Moreover, it is apparent that the learning facilitator that was observed could possibly intuitively have had a variety of metacognitive skills, but that learners were not given a suitable chance during the learning opportunities to assess their own thinking or comprehension, or given feedback on this (Table 5). A possible reason for this could be that the content and nature of the specific opportunities did not require this. Weinstein and Van Mater Stone (1993) found that learning facilitators in their research believed that the learners understood what they were supposed to learn, but that the learners were not assessed by themselves or the learning facilitator to obtain a decision on this matter.

We would like to emphasise the learning facilitator's own reflection on, and evaluation of, both learning opportunities (qualitative facet of the study). After the conclusion of both learning opportunities the learning facilitator expressed her concern about the inability of learners to explain a concept, or to explain what it was they did not understand. This inability is vitally important. According to the observation table (Table 5), since she felt that she knew what the work was about, she did no written planning. Although it was commendable that she knew what the work was about (or dealt with), we feel that a teacher should nevertheless plan the ways of presentation and how learning will take place. The teacher mentioned that, in spite of her own assessment, she did not plan to adapt similar learning opportunities in the future! This was most regrettable especially since Sternberg (1985) defines the evaluation of a learning opportunity as the planning for the facilitation of similar situations in the future. During observation of her conduct during the learning facilitation and the interviews preceding and following the conclusion of the learning opportunities, it became clear that she did not suitably reflect on possible ways to facilitate "best practice" in terms of mathematics teaching and learning in her classroom. These findings confirmed to a certain extent the finding of Black and William (1998) that learning facilitators know too little about their learners' learning needs. Clark and Peterson (1986) also confirm that learning facilitators perhaps concentrate too much on how to facilitate content and too little on learners' understanding. In our study, the learning facilitator probably did not have the relevant knowledge of recent approaches to learning facilitation in mathematics, namely, post-modern research on the theory and the practice of learning facilitation in mathematics (Hartman, 2001b). For this reason she was not capable of experimenting with the different learning facilitating approaches in her mathematics class and consequently the applicability and the effectiveness of the different approaches to learning facilitation in her class could not be evaluated (Borkowski, 2001).

Clearly, the learning facilitator's reflection was focused on the one-sided achievement of the set outcomes relating to content (and procedure) of the learning area mathematics and not on the learners' sufficient mastery of relevant metacognitive strategies. This is deplorable, since it is important that learning facilitators should consider their learners' mastery of metacognitive strategies. After all, one of the roles of the learning facilitator is to help learners become life-long learners (Jones, Bell & Saddler, 1991). Learners should become adept at distinguishing between what they know and what they do not know. In other words, they should be able to make a conscious decision regarding their knowledge about a problem. Furthermore, learners need to talk about their thinking in order to acquire a sufficient vocabulary to describe their thinking.

Concluding remarks

Learning facilitators' knowledge of their learning area, learners, and learning-facilitating strategies influence the quality of learners' learning (Ball & Bass, 2002). Planning, concerning (a) the subject concerned, (b) the learner him/herself, and (c) the learning facilitating strategy, is essential. Certainly, it is exactly these factors that make a teacher a good teacher! When a mathematics teacher plans for a learning opportunity he/she should also plan the metacognitive strategies according to the content of the particular learning area and also how he/she is going to teach the subject. The authors feel very strongly that all teachers should be guided to first acquire metacognitive skills to enable them to plan for and prepare their learners to think metacognitively and so be able to deal with mathematical problems in a metacognitive manner. To conclude we present a brief review of a possible logical and innovative way for teachers to guide their learners to function on a metacognitive level.

We concur with Koutseleni (1991), who asserts that when teachers teach learners different strategies to overcome obstacles to problem-solving, when learners are encouraged to think aloud, not only to provide a final answer to a problem, but also to explain the thought processes they made use of, teachers are actively supporting learners and guiding them to become aware of and use their metacognitive abilities. We also support Blakey and Spence's (1990) suggestions, which include the following: that learners keep a journal reflecting on their own thoughts, ambiguities and contradictions and comment on the obstacles that have been overcome; that learners explain and summarize their thinking processes during a class discussion; and that learners should initially be guided in their self-evaluation by a control list that focuses on thinking processes.

The substance of our argument is the following: It is impossible for learning facilitators to impart all the knowledge needed, or possibly needed in the future, by a particular age group of learners. On the other hand when learners are equipped with metacognitive strategies and skills — that cannot become obsolete — they are empowered to become independent lifelong learners (Bonds, Bonds & Peach, 1992).

Relatively little research has been done in the South African context on metacognition in mathematics teaching and even less has been published in this regard. The possibility that metacognitive skills and strategies unlock mathematics teaching are therefore relatively unknown to learning facilitators in South Africa. This creates an untenable situation, and we agree with Nxesi, President of the South African Democratic Teachers' Union (SADTU), who had the following to say about the poor quality of mathematics teaching in South Africa: "It is amazing that a national strategy for the professional development of teachers after ten years still does not exist" (De Vries, 2005).

Clearly, more research in this area is essential and, indeed, vitally important. Judging by the findings of this (albeit extremely limited and local study), the introduction of metacognition and the application of metacognitive skills and strategies in mathematics classrooms remains a major challenge for tertiary training institutions and schools alike. Seemingly, very few teachers either understand or apply these skills (put otherwise: address critical mass issues) in mathematics classrooms in South Africa. Teachers' epistemological assumptions and their classroom practices (based on these assumptions) need to be researched and challenged with a view to improving the standard of mathematics teaching in SA.

In summary, we have identified a number of important issues that we view as critical in mathematics classrooms, issues that need to be researched as a matter of extreme urgency. The first issue is that of an apparent and worrying failure on behalf of teachers to either provide knowledge of or insight into the concept metacognition. Secondly, we feel that it is vitally important to introduce the notion of metacognition and the application of metacognitive skills and strategies into South African mathematics classrooms, as a matter of extreme urgency, not in a top-down, prescriptive way that might fail to challenge the existing teachers' practices in the teaching of mathematics but, rather, by engaging practising teachers in in-service training and by introducing the notion of metacognition into lecture rooms at universities throughout South Africa, if we are serious about changing classroom practice. As we have indicated, any intervention should be based on the following principle: The mechanisms adopted need to start at the level where teachers are, i.e. the teachers themselves deserve a chance to share what they do in their classrooms and how they do it, as a starting point for reflection and critique. After all, we feel that it is vitally important to provide adequate opportunities for teachers to share in and benefit from cutting-edge knowledge from international research. Cluster meetings seem like a logical starting point to introduce these concepts. However, if our experience is anything to go by, a major problem in this regard appears to be the number of opportunities that exist in the clusters to engage in issues such as metacognition as opposed to the regulatory issues of policy, curriculum change structures and forms. The use of cluster meetings as opportunities to distribute and fill in forms and paper work on setting, moderating and grading question papers takes away the opportunity to focus the clusters on some significant areas of practice such as metacognition. In this way the existence of clusters as an informal place for teachers to carry out their own activities on content knowledge is minimized.

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Note

1. On account of the limited time at the disposal of the primary researcher, and because the investigation was a particular in-depth study, only one teacher was involved in the study.

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