Teachers' Use of Mathematics Tasks: The Impact on the Mathematics Learning and Affective Responses of Low-attaining Upper Primary Students

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Using a case study approach, this pilot study sought to investigate how teachers' use of particular mathematical tasks in the classroom impacts on low-attaining students. The perspectives of one teacher and two low-attaining students were considered in an attempt to investigate the interplay between task, pedagogy, affective responses and student learning. Four particular teacher actions, potentially beneficial for low-attaining students, were also examined.

The types of tasks teachers choose to use in mathematics classrooms have a significant impact on the kind of thinking students are afforded (Stein, Grover, & Henningsen, 1996), their level of engagement (Hiebert & Wearne, 1993) and their ability to build conceptual understanding of mathematical ideas (Henningsen & Stein, 1997). If teachers choose to use conceptually challenging mathematics tasks, the difficulty is to implement them so that their potential for higher-level thinking is maintained (Stein & Lane, 1996). For low-attaining students the cognitive challenge is often lessened or removed by the teacher (Boaler, 1997; Zohar, Degani, & Vaaknin, 2001). This indicates the key to maintaining high levels of thinking for low-attaining students are the teacher actions and pedagogy surrounding the task.

A particular concern evident in the literature is how to implement rich and conceptually challenging tasks for students who are low attaining in mathematics (Silver, Schwan Smith, & Scott Nelson, 1995; Woodward & Montague, 2002). There is a range of suggestions in the literature on effective teaching of low-attaining students. Ellis (2005) suggested that direct instruction was most successful for improving achievement for low-attaining students. Such instruction would include careful teacher explanations and scripted teaching, small groups, rapid pacing and drill. Kroesbergen, Van Luit and Maas' (2004) large-scale study investigated the use of constructivist teaching and explicit teaching for low-attaining students. Discussion of various student strategies, which then directed learning, characterised constructivist teaching sessions. Explicit teaching meant explicit attention was paid to the mathematical concepts by linking concepts to materials and was more teacher directed. This study found the explicit teaching group received slightly better results on tests developed by the researchers. Bottge and Hasselbring's (1993) findings suggested that teaching problem-solving skills and using contextualised problems had benefits for 36 adolescent remedial math students in their study. Larger projects such as the *Quantitative Understanding: Amplifying Student Achievement and Reasoning* project (QUASAR, Silver et al., 1995) found that the use of mathematics tasks which supported goals such as thinking, reasoning and problem-solving were successful with disadvantaged low-achieving middle school students in the United States.

Given this diverse range of advice, further research is needed on effective teaching approaches for low-attaining students on conceptually challenging mathematics tasks. Through an examination of the literature, I identified four potentially effective teaching approaches for low-attaining students that formed a framework for this study. The elements of the framework examined:

- The use of *manipulatives, representations, tools and materials* (e.g., Sowell, 1989)

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_ The use of *explicit teaching approaches* that highlights underlying mathematical concepts (e.g., Hiebert & Grouws, 2007)
_ The use of *scaffolding techniques* such as prompts, questions, and task variations (e.g., Anghileri, 2006; Sullivan, Mousley, & Zevenbergen, 2004)
_ The use of *discussion and discourse* to support student learning (e.g., Baxter, Woodward, Voorhies, & Wong, 2002)

Through this framework the present study sought to investigate the following research question:

How does the teacher's use of tasks, including specific pedagogies, impact on low-attaining students cognitively and affectively?

Method

This study was conducted within the context of a larger research project, the *Task Types and Mathematics Learning* project (TTML, Sullivan, Clarke & Clarke, 2007) that researched the opportunities and constraints teachers experienced when using four particular types of mathematical tasks. These task types were defined by the project as

_ Task Type 1: using concrete materials, tools or representations (e.g., Goldin, 1987);
_ Task Type 2: using real world contextualised problems (e.g., Lovitt & Clarke, 1988);
_ Task Type 3: using open-ended problems (e.g., Sullivan, Mousley, & Zevenbergen, 2006); and
_ Task Type 4: Tasks of an interdisciplinary nature (e.g., English & Watters, 2005).

This pilot study used a qualitative case study research design to build up a rich and detailed description of the mathematics experiences of two low-attaining students in one teacher's classroom (Merriam, 1998; Stake, 1995). The study drew on the work of Clarke's (2002) *complementary accounts* in that it sought to "deliberately [give] voice to many … meanings through accounts both from participants and from a variety of "readers" of those situations" (p. 2).

Participants

Ms B was a dynamic and passionate teacher of mathematics. She had five years of experience in teaching, with two years experience in teaching Year 5. Ms B was part of the larger research project, TTML. As part of her involvement in this project for two years prior to this study, Ms B attended professional development that focussed on trialling the four task types in classrooms and discussing the opportunities and difficulties (constraints) of using the task types.

For this study, two students in Ms B's Year 5 class were targeted for data collection: Laura and Lachie who had been assessed on standardised tests as operating 12 to 18 months below the expected standard for their age in mathematics.

Data Collection

Data about Ms B collected prior to lesson observations included an analysis of mathematics planning notes, the Teacher Beliefs Survey (Anderson, 1997), and a Tasks Questionnaire. During the data collection period, Ms B was interviewed before and after observed lessons. Data regarding Laura and Lachie were collected through lesson observations and the use of interview tasks after the observed lessons. Lesson observations occurred over four sequential mathematics lessons. On two of these days the lesson included two tasks making a total of six tasks observed. Table 1 provides a summary of the observed tasks.

Table 1
Overview of Observed Lessons

Task	Task description	Task Type
1	Two-way tables Posing two unrelated questions such as “Do you like chocolate? Do you play soccer?” and surveying classmates to construct a two-way table of the data.	TTML task type 2, using a real world context for the problem.
2	Average height of this class Investigate the heights of the students in the class and determine the median, mode and mean averages of the heights.	TTML task type 2, using a real world context for the problem.
3	Letters in a five word sentence Students are told that there is a sentence of five words with the mean number of letters of 4. They are asked to find solutions to how many letters could be in each word.	TTML task type 3, open-ended task.
4	Average height of a student at the school Students are asked to devise a strategy to find the student in their school with the mean average height.	TTML task type 2, using a real world context for the problem.
5	Fishing problem. Seven people go fishing. The mean number of fish caught was 5, the median was 4 and the mode was 3. How many fish might the people have caught?	TTML task type 3, open-ended task.
6	Data card sort. In groups the students are given 6 clues to a set of data. Using these clues they need to determine the set of scores.	TTML task type 1, using manipulatives, representation or tools.

Laura and Lachie were interviewed after each of the tasks. Creative interviewing tasks (Patton, 1990) were developed to assist the students in articulating their responses. The Emoticons Scale (see Fig. 1) asked the students to indicate their feelings about a task. The Learning Scale (see Fig. 2) asked students to reflect on the level of learning the task offered them ranging from “I learnt nothing new”, to “It made me think” then “I learnt something new”.

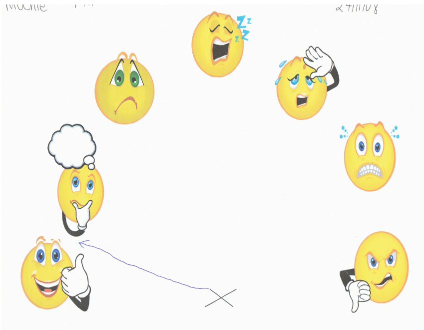

Figure 1. Emoticons scale reflection task.

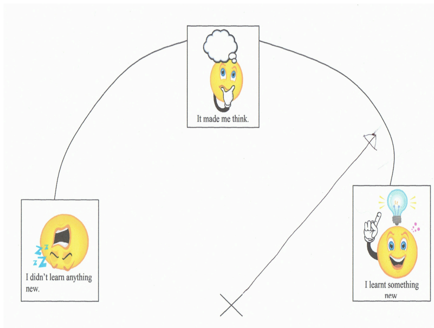

Figure 2. Learning scale reflection task

Results and Discussion

In order to discuss the themes that emerged from this study, I will use the four effective pedagogies that formed the framework of this study. There is some overlap between these four elements. However in the interests of clarity I have chosen to discuss each separately.

Manipulatives, Representations and Tools

Ms B's classroom had a large plastic tub containing mathematics equipment stored in the classroom. In the Tasks questionnaire Ms B wrote that "Ensuring all students know from the beginning of the year what concrete materials are available to them and where to find them" was important. For low-attaining students, Ms B felt that "Tasks using concrete materials or manipulatives" were amongst the most appropriate type of tasks.

Tasks observed during this study reflected Ms B's belief in the value of manipulatives. In addition, analysis of pre-observation planning notes revealed the use of websites, Excel spreadsheets, grids, maps, compass points or the physical environment such as the school. This contrasts with the findings of research showing that teachers' use of manipulatives and visual aides decreased in upper primary school classrooms (Howard & Perry, 1997).

Laura in particular appeared to enjoy Ms B's use of manipulatives and tools. Laura commented "it was fun going out to the learning area and doing the stripes [streamers] with everyone" (student interview, task 2). During the task it was noted "Laura and her partner started straight away to measure each other with the measuring tape and then cut a length of streamer of the same length. Laura seemed engaged and confident" (lesson observation notes, task 2).

Laura was also observed using tools in less mathematically productive ways. "Laura got a calculator and entered the numbers the leading girls read to her. This took a lot of time because the girls kept starting again" (lesson observation notes, task 4). Baxter, Woodward and Olson (2001) found that the low-attaining students in their study were often involved in "non-mathematical or low-level functional tasks" (p. 540). Similarly Laura was sometimes involved with her group or partner in such "supportive" rather than "substantive" ways (Baxter et al., p. 540). In these instances the use of tools such as the calculator appeared to give Laura a sense of purpose but did not seem to ensure her engagement with the mathematics of the task.

Lachie and Laura differed in the degree to which they considered using materials beneficial. Lachie used the materials provided in all the observed lessons but in contrast to Laura he indicated that he found other means more significant to support his learning than using materials. These are explored in the following discussions.

Scaffolding

Ms B provided scaffolding frequently throughout the lessons in the form of whole class scaffolding through initial tasks and discussions. At the end of lessons for example, Ms B was observed saying, "What did we need to know here? Is this accurate? What does this remind you of? Talk us through how you got your solution" (lesson observation notes, tasks 2, 3 and 5). Such questioning was often aimed at higher levels of thinking and usually demanded an explanation or justification in response. Although the wait time after such questions was short, these discussions potentially provided scaffolding for students about the mathematics of the tasks.

Ms B also provided individual scaffolding through her habit of speaking with each student or pairs of students while they were working on the task. When Ms B was talking with the students this way, she asked a lot of questions about the meaning of terms in the task, how what the student was doing could help, clarifying what the task was asking and discussing the students' strategies. Anghileri (2006) described this level of scaffolding as "reviewing" or "restructuring" by asking questions, interpreting student responses, highlighting important aspects of the task and using prompting or probing questions (p. 41). Ms B was most often operating at this level of scaffolding as she was observed asking students questions and probing their understanding of the task as demonstrated in lesson observation 3: "Lachie joined a group of students on the floor with the teacher. The teacher asked questions about mean and clarified the question. She probed the group to share strategies and thinking. One student suggested that there needed to be 20 letters in all because 20 divided by 5 words was 4. The students discussed this, then most left the floor able to make a start now after 5 minutes with the teacher. Lachie stayed on the floor. The teacher talked to him again for a minute or two asking questions and then he seemed more confident".

Laura and Lachie indicated that they appreciated Ms B's habit of offering scaffolding to them when needed. Lachie in particular mentioned Ms B's assistance in 5 out of the 6 tasks. For example, "The first part I was thinking and I was confused so I went down to my teacher and we talked about it and later when I knew what to do it got more fun" (student interview, task 4). This indicates that Lachie felt this individual or small group scaffolding was most beneficial for his learning and contributed to his positive feelings toward the tasks.

Discussion and Discourse

Discussion and discourse played a large and important part in Ms B's mathematics lessons as whole class discussions occurred for approximately half of each observed lesson. Furthermore students were directed to work with a partner or in groups for all of the tasks. This meant that for the entire lesson students could engage in conversation and discussion.

When Ms B used whole class discussions to explain the tasks, this appeared to lead to some confusion for Laura and Lachie who often required an additional discussion privately with Ms B in order to make a start. "When Ms B explained it and we were on the floor I didn't really understand it but then at my table, I put up my hand, Ms B came and helped me" (student interview, task 3). Both Laura and Lachie said that they were unsure about how to start the problem for four of the tasks despite Ms B's whole class discussion at the beginning of lessons. This indicated that for them, the initial whole class discussion did not ensure they could make a start however individual discourse with their teacher was beneficial.

During whole class discussions at the conclusion of lessons, Laura responded once with a short answer while Lachie was not observed participating in any of these discussions during this study. Baxter, Woodward and Olson (2001) reported that out of 34 observations, low-attaining students were observed making just 3 contributions. Baxter et al. (2001) proposed that classroom discussions placed “high cognitive and verbal demands on all students, who had to be able to understand and respond quickly to questions and comments by their peers as well as their teachers” (p. 538). Alternatively, Inagaki, Hatano and Morita (1998) suggested that silent students learnt as much as their vocal peers from whole class discussion and chose to remain silent listeners but participants nonetheless. It is not clear whether Lachie and Laura remained silent due to confusion or as listeners during these concluding discussions.

Regarding student discourse, Laura was observed discussing and working with classmates during all of the tasks. Lachie seemed to discuss the task with classmates less often. He was observed working alone unless specifically directed to work with a partner or a small group. These occasions were not highly successful in terms of Lachie’s learning. For example, after working with a small group, Lachie later expressed his frustration “They didn’t really cooperate. I just did my own thinking, they did their own thinking. They didn’t really help me” (student interview, task 5).

Explicit Teaching of Mathematics Concepts

Hiebert and Grouws (2007) proposed that teaching which promotes conceptual development in mathematics relies on teachers and students attending explicitly to concepts. Ms B believed understanding concepts was important as shown in her interview responses, for example, “And I guess that’s something I wanted to get across too, because it’s easy to give them the formula to find it, but if they don’t actually know why they're doing it then they're not going to remember that” (teacher interview, task 2). Ms B often used whole class discussion to highlight mathematical concepts. She made statements such as “Today we are going to talk about a different way to present information”. “Today’s task is to find the average height of 5B”.

Although Ms B was attending to underlying mathematical concepts, interviews revealed that Laura and Lachie did not always have a clear idea about the teacher’s mathematical purpose. Laura said that she thought the “teacher wanted me to learn how much people liked what you wrote down like if it was chocolate” (student interview, task 1). Lachie also said that the teacher wanted him to learn “about how many people like tennis or vegetables so you can learn how many people and what they like” (student interview, task 1). The focus of this task was the use of two-way tables rather than individual students’ food or sport preferences. The mathematical purpose in this instance was not clear to Laura and Lachie.

The mathematical intent of other tasks all focussed on the concepts of mean, median and mode. By task 6 Lachie had begun to focus more on these concepts. “I learnt about average which is adding up altogether. To get the average I think you have to divide it by … first add it up all then divide it by how many people you’ve got” (student interview, task 3). Although Laura could not articulate these concepts, she was observed making progress in her understanding. Ms B’s explicit attention to underlying concepts seemed to be gradually building Lachie and Laura’s mathematical understanding.

Conclusion

The present study sought to investigate the question of how a teacher's use of tasks impacted on two low-attaining students cognitively and affectively and examined four particular teacher actions as a frame for data analysis. The tasks observed in this study were conceptually challenging, aligning them more with constructivist teaching tasks (Kroesbergen et al., 2004), problem solving (Bottge & Hasselbring, 1993) and tasks aimed at thinking and reasoning (Silver et al., 1995) than with teacher-directed drill or direct instruction (Ellis, 2005).

This study found that the ways in which Ms B implemented such challenging tasks maintained the challenge. Ms B's refusal to lower the level of thinking that tasks demanded resulted in potentially rich mathematical experiences for her students. Her pedagogical approaches such as the use of visual representations and tools, attention to mathematics concepts, small group discussion and individual scaffolding were identified by the low-attaining target students as assisting them in their learning and contributing to their positive affective responses to tasks. Over the course of the observation period, Laura and Lachie could be observed building on previous experiences and began to demonstrate some understanding of the concepts behind the tasks. This suggests that Ms B's teaching methods had some success in both improving learning and maintaining positive affective responses of the target low-attaining students while implementing mathematically challenging tasks. Further research is required to examine this issue in greater depth.

Furthermore, Lachie and Laura illustrated the diversity that exists between low-attaining students with each highlighting different elements of Ms B's pedagogy that were most helpful to them. This emphasises that "one size does not necessarily fit all" and the need for teachers to consider a variety of strategies for assisting low-attaining students. This issue will also be investigated further in a larger study following this pilot.

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