Teachers' Extent of the Use of Particular Task Types in Mathematics and Choices Behind That Use

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As part of a larger project, *Task Types in Mathematics Learning*, through the use of a questionnaire, we sought middle years mathematics teachers' insights into the task types they chose to use in mathematics, the reasons for these choices, and the ways (if any) in which their choices had changed as a result of their involvement in the project. We found that teachers were able to articulate the reasons for their choices, and that both the choices and the reasons given varied considerably across the group. We also found that most teachers had changed their relative use of task types as a result of the project. Of particular note was the increased use of contextual tasks.

Mathematical tasks are important for teaching, and the nature of student learning is determined by the type of task and the way it is used (Kilpatrick, Swafford, & Findell, 2001; Sullivan, Clarke, Clarke, & O'Shea, 2009). It has been argued that the tasks set and the associated activity form the basis of the interaction between teaching and learning (Christiansen & Walther, 1986) and that "instructional tasks and classroom discourse moderate the relationship between teaching and learning" (Hiebert & Wearne, 1997, p. 420).

Stein, Grover, and Henningsten (1996) developed a conceptual framework that involved a set of differentiated task-related variables leading toward student learning. The model moved from the task as represented in curriculum materials to the task as set up by the teacher in the classroom, to the task as implemented by students in the classroom to student learning, including proposed factors, which may influence how the task variables related to each other.

When teachers pose higher order tasks, students give longer responses and demonstrate higher levels of performance on mathematical assessments (Hiebert & Wearne, 1997). The greatest gains on performance assessments, including questions that required high levels of mathematical thinking and reasoning, are related to the use of instructional tasks that engage students in "doing mathematics or using procedures with connection to meaning" (Stein & Lane, 1996, p. 50). A growing body of research has focused on the design and implementation of tasks, including problem situations, questioning methods, and activities for promoting student learning (Tzur, Zaslavsky, & Sullivan, 2008). Krainer (1993) claimed that, "powerful tasks are important points of contact between the actions of the teacher and those of the learner" (p. 68). As Silver and Herbst (2008) noted, "teachers' decisions and actions influence the nature and extent of student engagement with challenging tasks and ultimately affect students' opportunities to learn from their work on such tasks" (p. 55).

Herbst (2008, p. 125) distinguished between problem ("the mathematical statement of the work to do") and task ("the anticipated or observed deployment of one such problem over time, in the actions and interactions of particular people … doing particular operations with particular resources.")

Teacher knowledge can be crucial in task enactment. Charalambous (2008), who focused on tasks and the Mathematical Knowledge for Teaching (MKT), (Hill, Ball, & Schilling, 2008), contrasted the actions of a high MKT teacher who "largely maintained the cognitive demand of curriculum tasks at their intended level during task presentation and enactment" and a low-MKT teacher who "proceduralized even the intellectually demanding tasks she was

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using and placed more emphasis on students' remembering and applying rules and formulas" (p. 287).

Of particular interest in this study were the decisions teachers make in relation to their choice of tasks, and the relative benefit they attribute to different kinds of tasks. Anderson (2003) drew on responses to extensive questionnaires completed by 162 primary teachers in New South Wales. For the purpose of her study, she classified school mathematics questions as exercises, application problems, open-ended problems or unfamiliar problems. Exercises were claimed to be used "often" by 68% of respondents. Teachers believed that they provided practice in basic skills, particularly for low ability students, could be used to assess understanding, and enabled children to experience success. A common theme was that open-ended problems were challenging and therefore more suitable for more able students or students in higher grades. Anderson noted that the experience and confidence of the teacher appeared to be a major contributing factor in their choice of tasks, as were ability grouping practices, resource availability and assessment procedures.

Henningsen and Stein (1997) noted that, "the nature of tasks can potentially influence and structure the way students think and can serve to limit or broaden their views of the subject matter with which they are engaged" (p. 525). Students develop their sense of what it means to "do mathematics" from their actual experience with mathematics.

In this article, we describe briefly a project in which middle years' teachers and students were exploring the effective use of a range of task types in mathematics classrooms. We outline the task types, and then provide information of the relative use of these task types by individual project teachers, the changes in use they identified over the course of the project, and the reasons for their choices in this respect.

The TTML Project

In collaboration with teachers and students in Government and Catholic schools in three geographical clusters in Victoria, the Task Type and Mathematics Learning (TTML) project investigated the best ways to use different types of mathematics tasks, particularly in Grades 5 to 8. TTML was an Australian Research Council funded partnership between the Victorian Department of Education and Early Childhood Services, the Catholic Education Office (Melbourne), Monash University, and Australian Catholic University. Principal investigators were Peter Sullivan, Barbara Clarke and Doug Clarke. The author limit on MERGA papers restricted the list of authors for this paper.

Essentially the project focused on three types of mathematical tasks that we describe as follows:

Type 1: The teacher uses a model, example, or explanation that elaborates or exemplifies the mathematics. Such tasks are associated with good traditional mathematics teaching. The mathematical purpose is clear and the tools/models/representations are linked directly and explicitly. An example is a teacher who uses a fraction wall to provide a linear model of fractions, and poses tasks that require students to compare fractions, to determine equivalences, and to solve fractional equations.

Type 2: The teacher situates mathematics within a contextualised practical problem to engage the students, but the motive is explicitly mathematical. This task type has a particular mathematical focus as the starting point and the context exemplifies this. The context serves the twin purposes of showing how mathematics is used to make sense of the world and motivating students to solve the task. An example of this is: How many people can stand in your classroom? (Lovitt & Clarke, 1989) In this case, the task is "Imagine we have the opportunity to put on a concert in this classroom with a local band to raise funds for more school computers. How many tickets should we sell?" Here, the context provides a motivation for what follows and dictates the mathematical decisions that the students make.

Type 3: Teacher poses open-ended tasks that allow students to investigate specific mathematical content. Content-specific open-ended tasks have multiple possible answers and prompt insights into specific mathematics through students seeing and discussing the range of possible answers. An example is: A group of 7 people went fishing. The mean number of fish caught was 7, the median was 6 and the mode was 5. How many fish might each of the people have caught? The power of such tasks has been established by Cruz and Garrett (2006) and others.

These task types are not claimed to include all possible tasks and the categories are not mutually exclusive, with many tasks difficult to classify uniquely.

The project involved full day and after school professional learning sessions for teachers, some team teaching in classrooms, and considerable observation of teachers as they used the different task types in lessons. (See O'Shea & Peled (2009) for a more detailed description of the project.)

Elsewhere (see, e.g., Clarke, Clarke, Sullivan, O'Shea, & Roche, 2009), we have provided information on students' perceptions of those tasks that are most enjoyable and those from which they learn the most. Our focus in this paper is on the reasons behind teachers' choices of particular task types in planning and teaching.

Our research questions were the following:

- What is claimed to be the relative use of particular task types in the mathematics classroom by teachers who have participated in the TTML project for at least two years?
- What reasons do teachers give for their choices in this respect?
- How do teachers claim the relative use of particular task types has changed from what it was prior to their involvement in the project?

Methodology

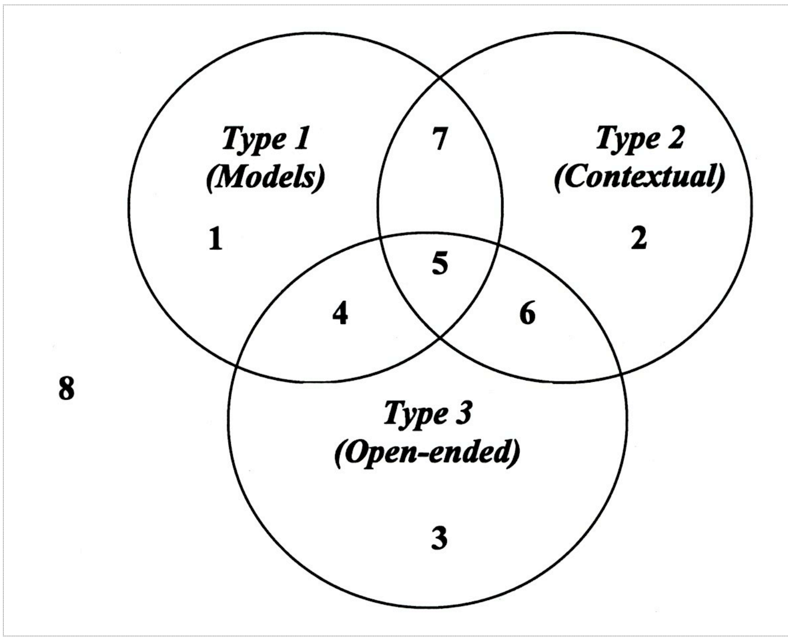
In the final month of the project, teachers were surveyed on their use of particular task types. The data discussed in this paper are derived from the responses of 16 teachers who had been involved in the project for at least two years. It was believed that extended experience in using the different task types provided a good basis for commenting on their relative use and merit.

The questionnaire items that form the basis of discussion within this paper are shown in Figure 1.

The element "8" in the Venn Diagram refers to tasks which were neither models, contextual or open ended and would include, for example, *exercises* (Anderson, 2003). Although it had originally been intended to survey the relative use of the three "pure" task types, as the project progressed it became clear that there was not always widespread agreement on classification. That is, very few tasks were seen by teacher participants and the project team as solely Type 1, 2 or 3. There was another survey item where teachers were given eight tasks and asked to locate each within the Venn Diagram. However, the results for that item are not included or discussed here.

In the TTML Project, we have explored the use of three types of tasks:
Type 1: Teachers use tasks that involve the introduction to, or use of models, representations, tools, or explanations, which exemplify the mathematics
Type 2: Teachers situate mathematics within a contextualised practical problem where the motive is explicitly mathematics
Type 3: Students investigate specific mathematical content through open-ended tasks
In our discussions, we suspect that some tasks have features of more than one task type, indicated by the numbers in the diagram below (e.g., #6 refers to tasks which are based on contexts and are also open-ended, but don't involve models).

(i) Please select the part of the diagram (No. 1 – 8) that best describes the types of tasks you most often choose to use when teaching mathematics and explain why.
a) Most common: # ❐
Reason why this is most common:
b) Second most common: # ❐
Reason why this is second most common:



(ii) Please select the part of the diagram that best describes the type of tasks that you would least likely choose when teaching mathematics and explain why.
c) Least likely choice: # ❐
Reason why this is the least likely to be chosen:

Figure 1. TTML teacher survey on use of task types, July 2009.

We acknowledge too that the mere statement of a task does not necessarily anticipate how a teacher will use it in a classroom, with, for example, the potential for a teacher to greatly "close" a potentially open task.

Results

In the next section, we discuss the relative use of different task types claimed by teachers. In the following section, we discuss the reasons given for these choices.

Relative Use of Task Types

In Table 1, we show the results of the responses to these items. The distribution of choices for the most common of the eight, the second most common, the least common, and the most common prior to the project are given.

Table 1

Frequencies of Use of Task Types in TTML Survey (n = 16)

	Part of the Venn Diagram							
	1	2	3	4	5	6	7	8
Most Common	2	2	1	2	2	5	2	
2nd Most Common	7	1	3	1		3	1	
Least Likely Choice	2	3	3		3			5
Prior to the Project	7	2	5	1	1			1

It should be noted that the frequencies for the item relating to teachers' use of tasks prior to the project add up to 17 because some teachers chose more than one task type in this item and others chose none.

As can be seen from Table 1, there was a considerable diversity of responses to the items regarding the most common and second most common elements within the Venn Diagram. Tasks, which were both open-ended and contextual, (#6) were rated by more teachers as most common than any other choice. However, tasks which were Type 1 solely (i.e., #1) were the most common response to "the 2nd most common" item. When the responses to "common" and "second most common" were added together, elements 6 and 1 were greater than the rest put together (totalling 8 and 9, respectively).

Element 8 (tasks which were neither Type 1, Type 2, nor Type 3) were not surprisingly the least common choice late in the project. We would see these task types as being largely exercises. It was also interesting that "pure" Type 1 tasks (# 1) and "pure" Type 3 tasks (# 3) were nominated most commonly as in greatest use prior to the project.

Although it is acknowledged that overlaps between task types are important, we decided nevertheless to rework the frequencies, to allow for the relative frequencies of tasks that had at least a component of Types 1, 2 and 3, respectively. Table 2 provides these data.

Table 2

Frequencies of Use of Task Types When Grouped in Main Categories (n = 16)

Parts of the Venn Diagram	Type 1 1, 4, 5, 7	Type 2 2, 5, 6, 7	Type 3 3, 4, 5, 6
Most Common	8	9	11
2nd Most Common	9	5	6
Least Likely Choice	5	6	6
Prior to the Project	9	4	7

It is clear from Table 2, that when grouped according to the original components (models, contextual, open-ended), there is little difference between the relative frequencies of the three, for most common, second most common and least common. However, it is interesting to note that, based on their responses to these items, teachers were clearly making greater relative use of contextual tasks towards the end of the project than prior to the project. Comments during professional learning sessions early in the project indicated that teachers found these the hardest to create themselves, but the greater identified use later in the project may indicate that teachers' confidence with generating appropriate contextual tasks had grown.

In the next section, we will discuss the reasons given for teachers' choices.

Reasons Given for Choices Related to Task Use

The teachers were able to articulate the reasons for their preferences and the perceived benefits or disadvantages of the tasks types for their students. From these responses, some themes emerged. These are now discussed for each task type:

Type 1: Models. Those who used Type 1 tasks more than others claimed that these tasks allowed for more explicit teaching and provided more structure for students who lacked confidence. The tasks were seen by some as providing opportunities to build a skill base and were usually more hands-on and practical. Type 1 tasks were noted to be more useful for teaching fractions, decimals and percentages and often included concrete materials. One teacher felt using Type 1 meant he/she was more "in control" and another suggested she/he used this task type to "build a knowledge base" and then practise using games. Only one teacher referred to the use of "games" in this survey, and this was in connection with the use of Type 1 tasks.

One teacher stated that these types of tasks were more "teacher driven" and did not allow for students to use different strategies or to problem solve. More teachers used these types of tasks prior to the project, and some worried that when used in isolation they were not meeting the needs of all students, and may have been less engaging than other task types.

Type 2: Contextual. Those who made most use of Type 2 tasks claimed that they were useful for connecting mathematics to the students' world, enabling them to become "more critical consumers and thinkers." One noted that "maths is more interesting and exciting when it has a real world purpose" and another felt that the problem solving context enabled concepts to be reinforced. Some noted that students enjoyed the challenge of these tasks and that they allowed students to "experiment with mathematical ideas." One teacher found it easy to provide contextual activities by using the newspaper, television and local events.

On the other hand, one teacher felt that some students struggled with tackling these types of tasks and sometimes had trouble knowing how to begin. Another teacher noted that these types of tasks can tend to take longer than other task types and may not be the best use of time for all students. One teacher found it difficult to develop contextual problems that genuinely linked to their unit of work.

Type 3: Open-ended. Those who made greatest use of Type 3 tasks stated that they were useful for catering for a range of abilities and could be used for assessment and as a "reporting tool." Several noted that open-ended tasks provided opportunities for the students to discuss their strategies or ways of solving problems and were sometimes a "springboard to other ideas." One noted that she/he predominantly used open-ended tasks (and contextualised tasks) for a unit on measurement. Another found that these were easy to develop and to link to their units of work.

In contrast, one teacher claimed that this type of task was used the least because they were used as assessment tasks only. Another only chose these tasks for students who were low achievers. One teacher stated that students needed more help to solve open-ended tasks and that it was difficult to determine what the students had learned. This teacher also found that they were difficult to use as an assessment item because it took time to analyse the responses.

As mentioned earlier, the most commonly used combination in the Venn Diagram was tasks which were both contextual and open-ended. One teacher explained her/his choice of these as follows: "Open-ended tasks are the easiest way to cater for different ability groups. The context enables students to engage with the task and therefore connect with the mathematics."

Conclusion

Overall, as a result of the TTML Project, most teachers stated that they were now more aware of the range of task types and looked actively for opportunities to use all three tasks types. They now felt able to select the task type that best suited the purpose or focus of the lesson and were more likely to choose tasks that catered for the range of abilities in their class. One teacher summed this view up as follows, reflecting on her/his prior focus on Type 1 tasks: “I felt in control of the content, wasn’t aware of the need to differentiate learning, or confident enough to allow students to develop their own strategies to problem solve.”

Teachers claimed to be now more mindful of providing a variety of experiences that allowed for a range of strategies and ways of thinking. Some noted that in particular the project had highlighted for them the use of contextual problems. For example, one commented that, “I think this project has highlighted contextual problems (genuine contexts) and also developed the understanding and recognition of all the elements which contribute to a rich task.” In an important paper on task complexity and task selection, Williams and Clarke (1997) noted that “the practical act of task selection can only be undertaken in the knowledge of the students for whom the task is intended and the purpose for which the task is being chosen” (p. 414). There is some evidence from our study that the teachers in the TTML project were increasingly making choices of task based on both their knowledge of students and a clear mathematical purpose.

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