(NEW VOICES)

Building an Igloo:
A Rich Source of Mathematics for Young Children

JANE KNOWLES provides a wonderful example of a rich, open and authentic task through which her young students learned a great deal of mathematics.

Early childhood teachers know that children arrive at school with an enormous range of mathematical capabilities but this is not always reflected in mathematics curricula that are offered. The diverse nature of the experiences young children have encountered before commencing school and their differing abilities to articulate their thoughts contribute to the diversity of informal mathematics that children have developed. According to Ginsburg (1996), formal mathematics instruction should be grounded in young children's informal mathematical ideas. Teachers need to bridge young children's informal mathematical knowledge with the more formal mathematics required at school and to support the development of young children's higher order thinking and metacognitive skills. Providing appropriate tasks can make an important contribution to this end. This article describes the mathematics learning that arose from one such task in a Prep class (first compulsory year of schooling in Tasmania) with children aged 5–6 years.

Appropriate tasks

Teachers need to provide children with learning experiences which are: challenging but achievable; "open" and related to a relevant context for them; learner centred;

and kinaesthetic in nature. Furthermore, tasks which are diagnostic in nature can also provide the teacher with important information about young children's mathematical ability. Taking the time to interview individually or conference with young children can provide great insight into their capabilities as learners.

Van de Walle (2004) advocated the use of a problem-based approach to mathematics teaching, because it allows all children to access tasks according to their own ability levels. Similarly, Zevenbergen, Dole and Wright (2004) described appropriate content for problem solving activities in the early years as focussing on the development of early number concepts such as: exploring patterns within numbers; working flexibly with numbers; verbalising thinking and solution strategies; developing benchmarks; and subitising and exploring number operations.

Students' perceptions of a subject are based upon the kinds of tasks performed and this in turn guides their expectations of mathematics (Hiebert et al., 1997). "What is important is that the teacher selects sets of tasks that connect with where students are and that lead towards the learning goals the teacher envisions" (Hiebert et al., 1997, p. 164). Consequently, when assessing children's understandings of a mathematical concept it is important for teachers to provide children with tasks which will enable them to exhibit their understandings effectively.

The igloo task

The task originated from the question, "What is an igloo?" raised by a student during a literacy lesson. Photographs of igloos were used both to help to answer this question and to tune students into the task of building an igloo from empty plastic milk containers brought to school by the students. The task was kinaesthetic and actively engaged the students in:

- counting for a purpose;
- reciting larger number sequences;
- estimation;
- counting with one-to-one correspondence;
- using counting strategies such as counting all, counting on, counting back and subitising;
- counting progressively larger collections;
- gaining an understanding of the continuous nature of number patterns.

The students actively engaged in the process of setting out the milk containers to form successive rows and kept a record of this process by circling the number of containers used at the completion of each row on a 100 chart. This 1–100 chart was later extended to accommodate numbers from 101–600. The containers were hot glued together by parents after each session. Figure 1 shows the igloo beginning to take shape.

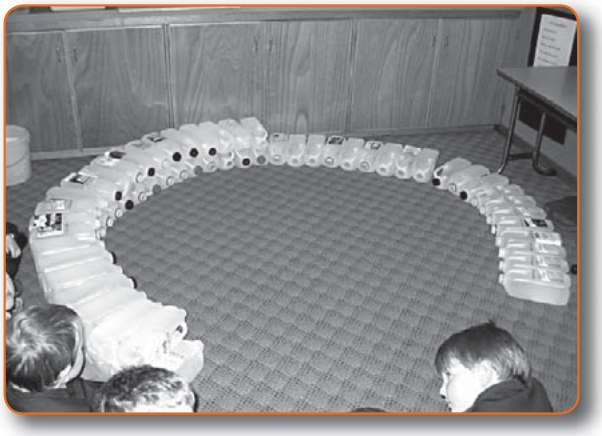

Figure 1. The first few rows of the igloo.

Once the igloo was high enough, the shape of the top was discussed along with reasons for the number of containers required for each row gradually reducing. Throughout the project the students engaged in mental computation, developed a sense of the relative size of whole numbers, expressed their mathematical ideas, engaged in mathematical thinking and reasoning, and became familiar with and employed appropriate mathematics terminology. At the end of the project, the students used the igloo as a reading centre and small groups of students played mathematics games inside it.

The following sections describe students' responses to the task in terms of their development of key skills and concepts related to counting and estimation. The responses of four students — Jarrod, Daniel, Michael and Kirsten — are highlighted and demonstrate the diversity of mathematical understandings present in the class.

Counting

Generally, initial number learning is accomplished by the rote learning or memorisation of language games such as rhymes and songs (Anghileri, 2000). According to Anghileri (2000) this is an important part of number learning and can provide children with their first experiences of counting forwards and backwards, and with opportunities to establish consistency in ordering number words.

The igloo task effectively highlighted the diversity in the children's counting strategies. It fostered the different counting strategies of different students and capitalised on their early number knowledge enabling all the students to challenge themselves and to use more sophisticated strategies such as "counting on" and "doubling," and to ask questions about the mathematics in which they were engaging.

Jarrod was able to recite the number sequence into the thirties and forties and was beginning to "count on" from numbers between one and thirty. For example, if asked what the number after 24 was, he could state it was 25. Throughout the igloo task, Jarrod appeared to become more confident in reciting number patterns through the decades (e.g., counted through 38, 39, 40). This was a significant advance for Jarrod, who had, until very recently, been struggling to count with one-to-one correspondence. Participation in the task exposed him to numbers beyond 100 and he began to say the correct number names for three-digit numbers when presented with the written numerals.

Michael was experiencing difficulty with reciting the teen numbers. For example, he rushed over the teen numbers, skipping the numbers from 12 and then recommencing the count at 20. He then started counting again at 24 and counted well to approximately 40. The igloo task enabled him to consolidate his knowledge of the number sequence in the teens.

Kirsten "counted on" to find the next number when containers were being placed in the row (e.g., if there were already 27 milk containers, she knew the next number would be 28). When the number of containers exceeded 100, Kirsten was still able to state the next number in the sequence until she got to about 130, at which point she became confused and started to count in tens.

For Daniel, whose mathematical understandings were relatively advanced, the task provided a context in which he could extend his knowledge of doubling numbers to much larger numbers than he had used before. Daniel also appeared to understand that the counting pattern kept on repeating through the decades, hundreds, and beyond. Throughout the task Daniel's mathematical thinking was extended through working with larger numbers, which he enjoyed. This is illustrated in the following exchange between Daniel and the class teacher:

Teacher: If there were 45 milk containers in the second row and each milk container held two litres of milk, how many litres of milk would that be?

Daniel: [Paused and thought about his answer] Ninety.

Teacher: How did you work that out?

Daniel: I know forty and forty is eighty; and five and five is ten; and eighty plus ten is ninety.

He was also able to work successfully with numbers over 500, as was evident when he correctly answered the following question: "If we had another igloo that had exactly the same number of milk containers (i.e.,

556) in it and put it on top of this one so that it reached the roof, how many milk containers would that be?" Daniel knew he needed to double the original number of milk containers to work out the answer and, although he did not articulate his thinking in this case, he may have used a similar strategy to the one he used when he working out the earlier question.

Estimation

Estimating is not a natural process, but one which children need to be taught explicitly (Zevenbergen et al., 2004). Appropriate explicit instruction requires children to engage in discussions about the reasonableness and appropriateness of their estimations, and the meaning and use of the terminology connected to estimation (Zevenbergen et al., 2004; Lang, 2001). They need experiences of modifying their estimates as more information is obtained, and of the differing effects of over-compensating and under-compensating when making their estimations (Zevenbergen et al., 2004; Lang, 2001). Estimation also requires the understanding of terms such as "more" and "less" (Zevenbergen et al., 2004; Thompson, 1997).

Prior to the igloo task, all the focus children found estimating small collections reasonably easy and appeared not to guess. Jarrod's estimation skills appeared to improve during the Igloo task. At the beginning of the task he estimated the number of milk containers needed to complete a row to be 100, when in fact it required approximately 40. By the end of this task his estimations became closer to the actual number (i.e., he used his knowledge of the number of milk containers in a previous row (43) and offered an estimate of 35). Furthermore, during discussions about whether there would be enough milk containers to complete a particular row he actively expressed a realistic opinion, particularly if there were too few containers. Jarrod demonstrated a growing understanding of the terms "more," "less," "estimation," as well as "counting on" "before" and "after" because he was able to use these terms correctly and hence was better able to articulate his thinking.

Michael made sound estimates when asked how many milk containers would be required to complete a particular row of the igloo. For example, he would use his knowledge of the number of milk containers in a given row to estimate the numbers of containers in subsequent rows.

Kirsten and Daniel provided appropriate estimations by using their knowledge of the number of containers in subsequent rows, even when the number of containers required for each row became increasingly small as the dome of the igloo was formed.

Conclusion

The igloo task was particularly effective in engaging the children in mathematical concepts such as estimating, counting strategies and mental computation. The task shared characteristics of tasks that have been identified as effective in engaging students and promoting effective mathematics learning. It was:

- kinaesthetic or "hand-on" in nature and actively engaged the children (Lindon, 2005);
- "open" and "rich," allowing the children to access it at their own level of ability, and learner-centred, targeting current levels of understanding (Gervasoni, 2005; Hiebert et al., 1997);
- challenging but achievable, that is, it was within the focus children's zone of proximal development (Reys, Syndam & Linquist, 1995);
- related to a real-life context which was relevant to the children;
- highly linked to play which promoted problem-solving, critical thinking, concept formation, creativity skills and

social and emotional development (Bergen, 2002).

The completed igloo is shown in Figure 2. The task specifically fostered an understanding of estimation, counting for a purpose, reciting of larger number sequences, counting with one to one correspondence, using counting strategies (such as counting all, counting on, counting back, subitising) and counting progressively larger collections in order to gain an understanding of the continuous nature of number patterns. It also encouraged the children to think mathematically as it was a relevant and purposeful real-life problem-solving situation requiring the application of appropriate skills and thinking about the mathematics they were using. The task enabled the children to consolidate their knowledge of number sequences and encouraged them to use more sophisticated counting strategies. It enabled the children to challenge themselves to a level where they felt comfortable, which supported Lindon's (2005) view that young children can gain an understanding of abstract ideas within a familiar context that encompasses hands-on exploration.

Teachers may consider incorporating similar investigations in order to engage children in tasks which are "open" and relevant and are cross-curricular in nature or are inspired by the curiosities of the children. Tasks of this nature can assist children to build on their informal knowledge of mathematics and to assist in bridging the gap between young children's informal knowledge and the more formal school mathematics.

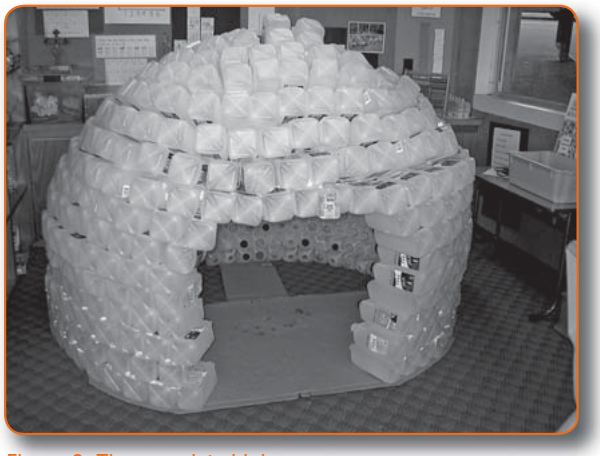

Figure 2. The completed igloo.

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Jane Knowles
Larmenier School, Tas.
<jane.knowles@catholic.tas.edu.au>