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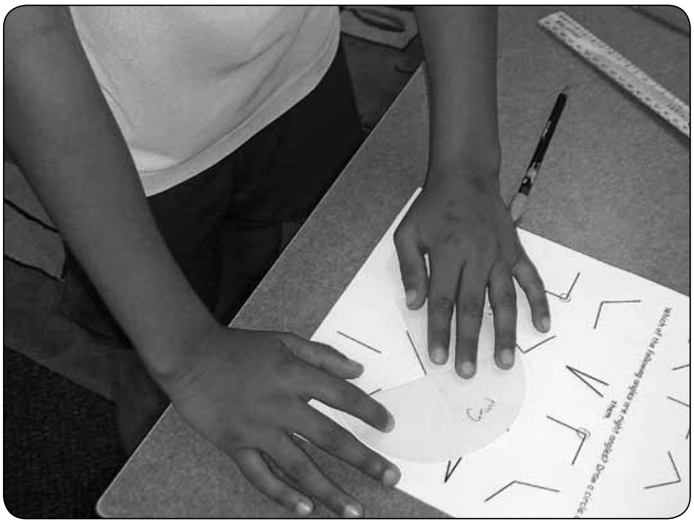

Heavy Thinking: Young Children's Theorising About Mass

AMY MaCDONALD

analyses young children's thinking about the concept of mass.

Background

Recently, my colleague and I wrote about how asking young children to draw a clock can reveal the experiences with, and understandings of, time which young children possess (Smith & MacDonald, 2009). This open-ended drawing task allowed the children to represent an understanding of time which was meaningful and personalised, and in doing so to make sense of the concept of time in their own way. In this article, I describe a similar open-ended drawing task which was used to discover young children's experiences with, and understandings of, the concept of mass.

Mass is defined as the amount of matter in an object, and, like time, it cannot be seen (NSW Department of Education and Training Professional Support and Curriculum Directorate [NSW DET PS&CD], 2003). As a consequence of its invisibility, children often find the concept of mass difficult to understand (Gifford, 2005). In order to construct their understanding of mass, children usually refer to their personal experiences. Understanding is drawn from specific activities, such as weighing people and moving heavy objects (Gifford, 2005). These experiences vary from child to child, reflecting their different home environments, family interests, and personal circumstances. Everyday experiences provide opportunities for children to explore mass in familiar environments, discovering its properties, and thus constructing their own knowledge (Charlesworth, 2005).

One way children can communicate their understandings about mass is by drawing, and providing explanations of their drawings. Similar to the 'draw a clock' task referred to earlier, children in their first year of formal schooling (aged 4 to 6 years) were asked to draw something heavy and something light, and to describe their drawing. This process, which Wright (2007) has termed "drawing-telling", captures the ways in which children make sense of the concept of mass, and identifies the prior experiences and background knowledge brought to the concept by the children (Woleck, 2001). Upon viewing the drawings and accompanying stories, it became clear that the children used these prior experiences and background knowledge to construct their own personal 'theories' about mass. The following sections present the four theories that were identified by the children. It should be noted that some of the children's work evidenced more than one theory.

Theory 1: If an object can be picked up, it is light

A common theory about mass presented by the children in their drawings related to whether or not they could pick up an object. Usually, this assertion was based on specific occurrences experienced by the children. For example, Blake's drawing was a representation of his personal experiences with trying to lift different objects (Figure 1): "A cat is light and a motorbike is heavy. I tried to pick up my cat once and it was light. I couldn't pick up my motorbike because it was too heavy." Hannah also described a personal experience in her drawing: "A hotel is heavy because you can't pick it up. A feather is light because my chook lost a feather. I picked it up and it was light."

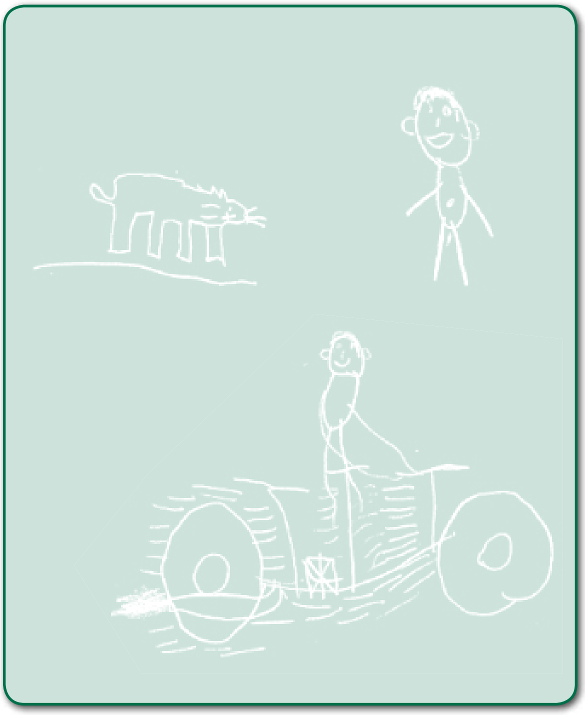

Figure 1. Blake's drawing.

In addition to describing whether or not they could pick up an object, some students were able to represent themselves comparing the masses of items by holding them in their hands—a process known as 'hefting'. Abby explained, "I can weigh things to see if they are heavy or light. If I can't lift something it is heavy. If I put things in my hands and weigh them, the hand that goes down is the heaviest." Caitlin also compared the masses of objects by imagining she was holding them: "The mermaid is heavy and the butterfly is light. I know the mermaid is heavy because I'm imagining I'm holding the mermaid and the butterfly, and the mermaid feels heavy."

These personalised understandings provide a useful starting point when teaching about the measurement of mass. Already, these children show some knowledge about inertia—that is, the amount of response to a force applied to the object. The children also show awareness of the downwards pressure experienced when objects are held or lifted (Booker, Bond, Briggs & Davey, 1997). From here, the children are able to progress to more formal engagements with mass measurement, using a variety of balances to weigh everyday items.

Theory 2: The bigger an object is, the heavier it is

A common misconception is that larger things weigh more (Gifford, 2005). This is a theory of mass which most of the children ascribed to, and they were able to articulate its application clearly. William chose to draw a picture of a flower and a house, explaining "[A flower is] light because it's very little. If it was bigger, it would be heavier. A house is heavy because it's big." Lachlan offered a similar theory with his drawing of a series of carrots (Figure 2): "These are carrots. Some are little and some are big. Carrots are light, but the biggest one is heavy. When things are big, they are heavy. The bigger they are, the heavier they are."

Figure 2. Lachlan's drawing.

Clearly, an object's mass may not be proportional to its volume (Booker et al., 1997). As the NSW DET PS&CD (2003) point out, "students may confuse mass and volume because objects with a larger volume will often have more mass that those with a smaller volume" (p. 114). One of the most important issues in teaching about mass, therefore, is to distinguish it from volume (Booker et al., 1997). Children need to be given opportunities to experience and discuss large light things and small heavy things. Additionally, "if two contrasting materials are compared, for example, foam packaging and iron, students will quickly realise that the larger volume does not necessarily have the larger mass" (NSW DET PS&CD 2003, p. 114).

Theory 3: If things can fit inside an object, it is heavy

Several of the children classified objects as either heavy or light based on whether or not things could fit inside the object, for example Kody, who drew a toy car and a fridge (Figure 3) said, "That's a toy car. It's not heavy because people can't fit in it. That's a heavy fridge. It's got heaps of things in it and it's stuck to the ground." Zac also based his theory of mass on his experiences of heavy things being those which have other things inside them: "A shoe is light because it doesn't have anything inside it. A truck is heavy because it has heavy stuff inside it. It is very big and that makes it heavy." Additionally, Zac incorporated notions of

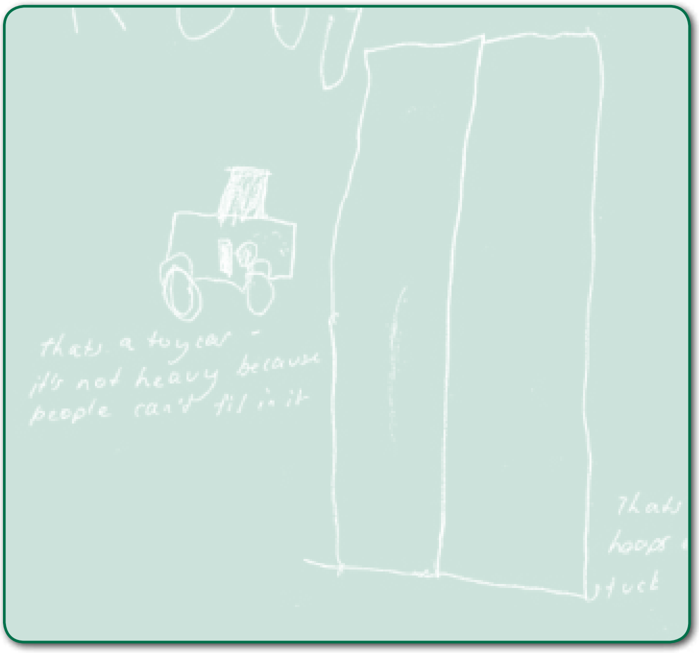

Figure 3. Kody's drawing.

Theory 2 in his explanation—that is, that "big" equates to "heavy".

As evident from Zac's explanation, Theory 3 is closely related to Theory 2 in that it makes reference to an object's capacity; the logic being that the more "stuff" can fit inside an object, the heavier it must be. Again, children must be provided with hands-on experiences which demonstrate that a larger capacity does not necessarily mean a greater mass. Children can explore this notion using a variety of different sized containers, and filling these with a range of different objects of varying sizes and masses.

Theory 4: If an object floats, it is light

This interesting theory was put forward by Sarah, whose drawing showed a rock and a piece of paper (Figure 4). Sarah applied her own theory of mass when classifying the objects, explaining: "That's a big rock. It's heavy because it doesn't float and you can't pick it up. That's a piece of paper. It's light because you can pick it up and it floats."

It seems from Sarah's explanation that her classifications were in fact based on the property of *density*, rather than mass. Density can be defined as mass per unit volume, with different materials having different characteristic densities (Smith, Snir & Grosslight, 1992). Children can have difficulty in comprehending and untangling the related properties of mass and density: their confusion might be justified and profound because what it means for something to be high in density is sometimes explained to children as being "made of heavy stuff" (Kohn, 1993). In order to overcome misconceptions such as Sarah's, children need to be given practical examples which distinguish mass from density. Activities which explore objects of the same size but that have differing masses, e.g., balloons filled with air, water, and sand, are a useful way of demonstrating that although objects may take up the same amount of space (i.e., same volume) they may weigh different amounts (i.e., have different masses). This principle can be extended to the concept of density by exploring 'sinking' and 'floating' with a variety of objects, and it may be useful to draw children's attention to heavy objects that float, e.g. ships. It may also be useful to experiment with materials which may sink *or* float, depending on their form.

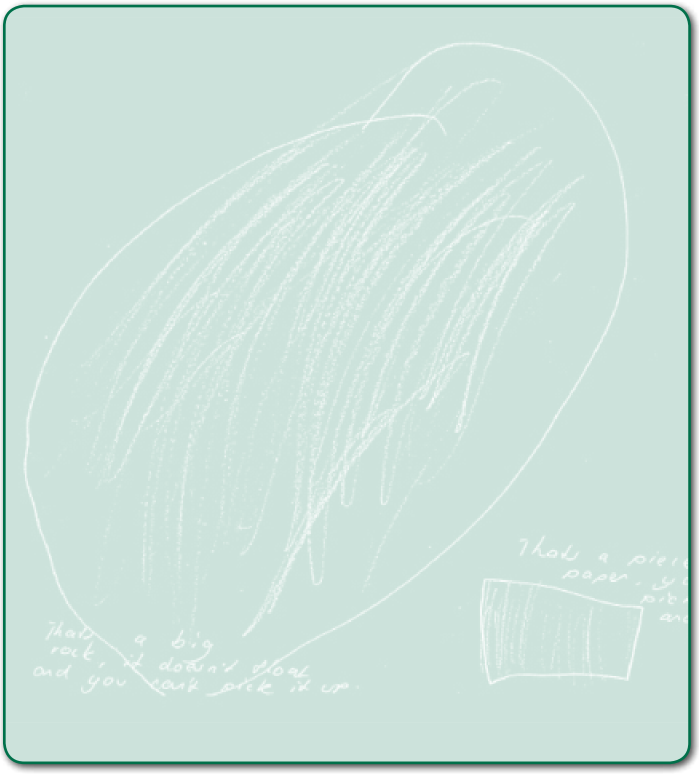

Figure 4. Sarah's drawing.

For example, plasticine, when rolled into a ball, will sink; however, when remoulded into a 'cup' shape (allowing air into the centre), it will float. This will help to demonstrate the conceptual underpinning of a floating ship, that is, that heavy materials may float if there is enough air inside of them.

Concluding thoughts

As the previous examples outline, through personal, naturalistic engagements with measurement, children come to learn first-hand the characteristics of mass. However, it is important to note that some of these experiences may lead to misconceptions about mass. A rational error in mathematics is one which is inherently logical—that is, it makes sense to the person who created it (MacDonald, 2008). These types of misconceptions are generally based on prior knowledge and personal experiences. For example, although it is not always 'true' that large objects have greater mass, there are many circumstances that children may have experienced where this *is* the case, thus leading children to believe that this is *always* the case. By allowing children to represent their understandings about mass in meaningful ways, we are able to identify the prior experiences with the concept which they have, and also identify at an early stage any misconceptions which may be held. It is important to note that these misconceptions still have value because they are generally formed out of real life experiences, and it is these experiences that provide the most meaningful starting points for mathematics learning.

While drawing-telling is a powerful medium for accessing children's experiences with mass, it must be acknowledged that there are some limitations to this approach. Children's responses will undoubtedly be influenced by their ability to draw and the vocabulary they possess (Smith & MacDonald, 2009). Additionally, the responses will reflect the children's willingness to draw or speak, as well as the children's individual interpretations of the task itself (Smith & MacDonald, 2009).

Despite these limitations, drawing-telling can be considered a useful activity for teachers wanting to uncover children's personalised experiences with, and understandings of, mathematics concepts. With reference to the specific example of mass, the drawing-telling task of representing something heavy and something light uncovered a range of 'theories'—both accurate and otherwise—which children have developed about mass as a result of their engagements with the concept. These engagements provide a meaningful starting point for more formalised teaching about mass, and allow students to connect the mathematics they have encountered outside of school to the content they are presented with in the classroom.

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Amy MacDonald
Charles Sturt University
<amacdonald@csu.edu.au>

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